MODULE
10

Effective oral and mental work

OBJECTIVES

This module is for study by an individual teacher or group of teachers. It:

- considers the importance of oral and mental work in all parts of mathematics lessons;
- discusses how to develop a programme of oral and mental starters.

CONTENT

The module is in four parts.

1 Introduction

2 Oral and mental starters

3 Oral and mental work in the main part of the lesson and the plenary

4 Summary

RESOURCES

Essential

- Your personal file for inserting resource sheets and making notes as you work through the activities in this module
- The *Framework for teaching mathematics: Years 7, 8 and 9*
- Video sequence 6, Oral and mental starters, from the DVD accompanying this module, and a DVD player
- The resource sheets at the end of this module:
  - 10a Features of oral and mental starters
  - 10b Reflections
  - 10c Plan for an oral and mental starter
  - 10d Equilateral triangles
  - 10e Types of question
  - 10f How children travel to school
  - 10g Transformations
  - 10h Plan for a plenary
  - 10i Summary and further action on Module 10

Desirable

The National Numeracy Strategy publication *Mathematical vocabulary*, which you can download from:
www.standards.dfes.gov.uk/numeracy/publications/resources/vocabulary/MathematicalVocabulary.pdf

STUDY TIME

Allow approximately 90 minutes.

Part 1 Introduction

1 This module emphasises the importance of oral and mental work in all parts of a mathematics lesson. Effective oral and mental work is important because:

- it is the basis of good interactive teaching;
- it engages and motivates pupils;
- it models and practises the speaking, listening, discussion and thinking skills which pupils need to develop.

The first half of the module discusses how to establish a regular programme of oral and mental starters to lessons. In the second half, we look at the use of oral and mental work in the main part of the lesson and the plenary.

Part 2 Oral and mental starters

1 There are several purposes of a short, focused oral and mental activity at the start of a lesson. The activity may be designed to fulfil one or more of these aims:

- To ensure that the lesson gets off to a purposeful start and sets a brisk pace
  For example, having a puzzle on the board as pupils arrive can be a good settling activity (e.g. arithmagons, magic squares with algebra, graphs that need explaining). Once pupils have had a chance to work on the puzzle, discuss the strategies they have used.
- To rehearse previously taught skills in a variety of lively ways
  The wide range of skills that can be practised include mental calculations of all types, simple algebraic manipulations, estimations of measurements and calculations, visualisation skills involving imagery, interpretation of graphs and charts, and so on. It is all too easy to forget facts if you don't have regular opportunities to recall them. Occasional practice of recall of prime numbers to 100, addition and subtraction facts to 20, conversions of units of measurement (including time and speed), fraction, decimal and percentage equivalents, multiplication and division facts and so on fall into this category.
- To focus on the skills needed in the main part of the lesson
  If you pre-empt problems and rehearse skills at the start of the lesson, pupils are able to work without interruption later on. Examples might be practising cancelling fractions as preparation for work on probability; doing calculations such as 12 ÷ 0.5 before calculating coordinates of the graph y = 12/x.
- To make use of homework from a previous lesson in an introductory activity
  For example, pupils may have collected some data and may discuss at the start of a lesson how best to organise it; they may have done some calculations in preparation for comparisons of calculation methods, or solved a geometric problem in readiness for sharing explanations of their reasoning.
- To make an informal assessment of pupils' understanding and progress in order to inform the direction of the next part of the lesson
  Making sure that you get feedback from a high proportion of pupils – for example, by using mini-whiteboards or by using targeted questions – allows you to make a rapid informal assessment of the group. This can help ensure that the lesson is pitched at an appropriate level so that pupils' knowledge and understanding can be consolidated and extended. It also provides an opportunity for misconceptions to be identified and rectified immediately or noted for tackling later.

2 You now have an opportunity to watch a selection of oral and mental starters. Get ready to watch **Video sequence 6, Oral and mental starters**. While you are watching, note any examples of the features listed on **Resource 10a, Features of oral and mental starters**.

Watch the video sequence, which lasts about 8 minutes.

When you have finished watching, spend a few minutes completing the notes you have made on Resource 10a.

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3 Item 1 above described a number of general purposes of oral and mental starters. The starters can also be used to help meet a wide range of mathematical objectives. For example:

- Develop and explain mental calculation strategies, including figuring out new facts from known facts and explaining the strategies used
  A strong emphasis on explaining strategies helps other pupils to increase their repertoire of skills. Pupils should be encouraged to consider the efficiency, reliability and applicability of their own and others' strategies.
- Apply number facts to real-life situations
  Pupils should apply number facts and calculation strategies to solve word problems and real-life problems which involve more than one step, money problems and problems using units of measurement.
- Develop estimation skills
  Developing estimation skills is an important element in the use of calculators. Pupils need quick recall of number facts when dealing with decimals – for example, estimating 0.221×5.17 as $0.2 \times 5 = 1$ to check that the calculator answer is of the correct magnitude.
- Develop links between the laws of number and those of algebra
  The Key Stage 3 Framework has an important message: that algebra is generalised arithmetic. Pupils should have a good grasp of solving algebraic equations mentally before progressing to more formal methods.
- Develop mental imagery of shapes, movements and constructions
  Pupils need to be able to visualise geometrical shapes, consider their properties and relationships, and analyse their transformations, giving reasons for their results and conclusions. These skills underpin the development of geometrical proof.
- Develop inference skills from data in a variety of forms
  Pupils need to be able to analyse and make inferences from data. The oral and mental starter is a good time to ask pupils to look at graphs, charts and tables, to describe their observations, and to justify their conclusions or hypotheses.
- Develop the use of correct mathematical vocabulary
  Pupils need to use correct mathematical vocabulary and notation, and understand the meaning of mathematical terms. They may fail to answer correctly because they are not familiar with the correct terminology. This can give rise to confusion between, for example, an expression and an equation, and the instruction to simplify or to solve.
- Develop the ability to generalise, reason and prove
  Pupils need to develop the ability to generalise, reason and prove. They should be able to give a justification for an answer and to see the difference between demonstration and proof.

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4 Use **Resource 10b, Reflections**, to consider the features identified in paragraph 3 above. Which of them do you use regularly in your own lesson starters and which might you think about using more frequently?

5 Section 4, the supplement of examples, of the Key Stage 3 Framework has a wide range of examples of activities that can be used as oral and mental starters.

Use **Resource 10c, Plan for an oral and mental starter**, to design an oral and mental starter activity of a type that you don't use regularly. You will first need to identify a learning objective for the activity and a class with whom to trial it.

Part 3 Oral and mental work in the main part of the lesson and the plenary

1 Many schools have gone a long way towards establishing regular oral and mental starters to lessons. It is equally important to engage pupils in effective oral and mental work in later parts of the lesson.

Many lessons, though not all, will involve some focused teaching at the start of the main part. Where the lesson is partway through a topic, this might be in the form of a short reminder about what happened previously, stressing key ideas, vocabulary and particular techniques, for example. It will also be the time to ensure that all pupils know what they are to work on in this lesson. At the start of new topics and at key points throughout them, the direct teaching input will be more substantial. In each of these situations, pupils should be deploying and practising their oral and mental skills through interactions with their teacher.

We are going to look at three examples of main teaching activities that focus on particular oral and mental skills.

2 **Example 1: Solving problems in geometry**

In the first example, Year 8 pupils practise their listening skills and powers of mental imagery. The objectives for main part of the lesson are that pupils will be taught to:

- solve geometrical problems using side and angle properties of equilateral triangles, explaining reasoning with diagrams and text;
- use logical argument to establish the truth of a statement.

Read through the 'script' in **Resource 10d, Equilateral triangles**. Try to put yourself in the shoes of a pupil, and respond accordingly.

3 In a real class, the introduction to the main activity on Resource 10d ought to engage everyone in thinking about the properties of shapes. It should also give you the chance to make a quick assessment of pupils' confidence and familiarity with the ideas and the language. At the conclusion of this activity, the class should be aware that three different shapes can be made from four equilateral triangles. Two of these three shapes form the net of a regular tetrahedron.

Now consider what the next part of the lesson might look like. Make some notes on how it might develop in your personal file.

4 One possibility for further development would be to address the question: 'How do we know when we have found all the possible shapes made from four equilateral triangles?'. Another would be to extend the idea to five triangles and ask pairs or groups of pupils to classify their findings according to a criterion they choose (for example, the order of rotation symmetry).

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5 **Example 2: Data handling**

The second example focuses on the design and use of questions to engage pupils' thinking.

Before you look at the example itself, read **Resource 10e, Types of question**. This is based on the National Numeracy Strategy publication *Mathematical vocabulary*, which you can download from the DfES Standards website (for the web address, see page 1).

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6 We will now consider a Year 7 class that has been collecting data and representing it using a computer spreadsheet. The teacher wants to begin exploring appropriate and inappropriate use of computer charts. The unit's objectives include: 'interpret diagrams and graphs, and draw inferences'.

Look at **Resource 10f, How children travel to school**. The two graphs are different ways of representing the same set of data. Imagine that you have shown the graphs to a Year 7 class. Use Resource 10f to jot down some questions that will establish how well pupils are able to interpret the first graph. Then jot down some questions that would encourage pupils to compare the relative usefulness of the two graphs.

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7 Do your suggested questions related to the bar chart include both open and closed questions?

Examples of closed questions might include:

- *How many boys travelled by bus?*
- *How many more girls than boys travelled by car?*
- *How many children were in the survey?*
- *About a quarter of pupils used one form of transport. Which was it?*

Examples of open questions might include:

- *What does the graph show?*
- *Approximately what percentage of pupils walked? How did you work it out?*
- *How can you be sure?*

Questions which would encourage pupils to compare the relative usefulness of the two graphs might include:

- *Which is the better way to present this information and why?*
- *On the line graph why are the points joined by a line? Is there a meaning to values between the points?*
- *How would you decide which graph to use?*

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8 **Example 3: Transformation geometry**

In this third example, we will look at how to generate meaningful group discussion. It is taken from a Year 9 class who are coming to the end of a unit on transformation geometry. This included the objective: 'recognise and visualise transformations and symmetries of 2-D shapes'.

Resource 10g, Transformations, shows a diagram that is provided as part of the department's resources for the unit. Assume that you want to use it to assess both how well the pupils understand the different transformations they have met and how well they can use the associated mathematical terms. Use Resource 10g to jot down some probing questions designed to encourage discussion among pupils in groups. The questions should help you to listen in and assess pupils' understanding and use of language.

9 During longer lessons, it can be useful to bring pupils together to gauge how they are progressing and to check for misconceptions. Often, though not always, such plenaries will be at the end of lessons. A suitable oral and mental session at this point enables a teacher to do a number of things: assess progress; identify misconceptions; decide whether pupils are repeating an error; and consider whether they are ready to move on or require further teacher input to make progress. All this helps to ensure that a good pace is maintained and that teaching remains appropriately targeted.

Use **Resource 10h, Plan for a plenary**. Using Example 3 above, consider how you would bring the class together for a plenary designed to confirm what pupils have learned and to reveal any remaining misconceptions.

Part 4 Summary

1 Improving the quality of pupils' oral and mental skills is a key objective in improving standards of mathematics learning nationally. Many departments have identified improving questioning and discussion as targets for development work.

If possible, discuss your plans for an oral and mental starter and plenary with your head of department, an advisory teacher or an experienced colleague. Ask for feedback on:

- whether the plans would be effective in teaching pupils to articulate their ideas and explain and justify their reasoning;
- whether the plans cater sufficiently well for pupils' different needs and abilities;
- whether the questions that you will use will probe pupils' thinking and help to extend their oral and mental skills.

2 Look back over the notes you have made during this module. Have you identified all the factors that you want to consider and adopt when you are thinking about oral and mental work?

Use **Resource 10i, Summary and further action on Module 10**, to list key points you have learned, points to follow up in further study, modifications you will make to your planning or teaching, and any points to discuss with your head of department.

3 To follow up your work on these modules, you could try to visit a lesson taught by a leading teacher. Ask your head of department about your LEA's arrangements for this.

Resource 10a Features of oral and mental starters

Note examples from **Video sequence 6, Oral and mental starters**.

To what extent did teachers in the video sequence:

- have high expectations of pupils?

- provide a purposeful start to the lesson?

- identify clear learning outcomes?

- ensure that all pupils can and do take an active part in the session?

- prepare a good range of suitably differentiated open and closed questions to ask the class?

- target individuals, pairs or small groups with particular questions?

- use pupils' responses to assess understanding and progress?

Resource 10b Reflections

I use oral and mental starters:	Often	Sometimes	Rarely	I'd like to strengthen this feature of my teaching
to develop and explain mental calculation strategies, including figuring out new facts from known facts and explaining the strategies used				
to apply number facts to real-life situations				
to develop estimation skills				
to develop links between the laws of arithmetic and those of algebra				
to develop mental imagery of shapes, movements and constructions				
to develop inference skills from data in a variety of forms				
to develop the use of correct mathematical vocabulary				
to develop the ability to generalise, reason and prove				

In this space, note any actions that you need to take to strengthen the features you have selected. Note also any points that you would like to discuss with your head of department.

Resource 10c Plan for an oral and mental starter

Teaching group and objective(s)

Key vocabulary

Notes on organisation, activity, key questions

Resource 10d Equilateral triangles

Read through the instructions below, a teacher's 'script' for the first part of the main teaching activity in a Year 8 geometry lesson. Try to put yourself in the shoes of a pupil, and respond accordingly. Don't rush – give yourself plenty of time to think. You should avoid any drawing or sketching and use mental images only.

The right-hand column is for you to note your responses to the bulleted questions, **using words only**. (In a real lesson, the teacher would ask one or more pupils to respond orally, using correct terminology.)

Imagine an equilateral triangle. *Imagine another identical equilateral triangle. Place it alongside the original so that the edges match exactly.* • *What is the name of the shape you have made?* • *Is there more than one possibility?* • *Explain how you know.*	
Take another identical equilateral triangle and add this to the figure. • *What is the name of the shape you have made?* • *Describe its properties as accurately as you can.* • *Is there more than one possibility?* • *Explain how you know.*	
Take four identical equilateral triangles. *How many different shapes can you make by joining edges?*	
Describe as accurately as possible one of the shapes you have made from the four equilateral triangles. *(In a real lesson, other pupils would be expected to sketch on their mini-whiteboards the shape being described. The shapes would then be revealed and compared.)*	
• *What is the name of the shape you have made?* • *Describe its properties as accurately as you can.* • *What are the symmetries of your shape?* • *Could it form the net of a regular polyhedron?*	

Consider whether this script would work if equilateral triangles were replaced by squares or by right-angled triangles.

Resource 10e Types of question

The use of questions is crucial in helping pupils to understand mathematical ideas and use mathematical terms correctly. Different sorts of question stimulate different sorts of thinking in pupils. It is easier to use certain types of question – those that ask the listener to recall and apply facts – than those that require a higher level of thinking. It is important to plan to use a full range of questions in your lessons.

Recalling facts

What is 3 add 7?

How many days are there in a week?

How many centimetres are there in a metre?

Is 31 a prime number?

Applying facts

Tell me two numbers that have a difference of 12.

What unit would you choose to measure the width of the table?

What are the factors of 42?

Hypothesising or predicting

Estimate the number of marbles in this jar.

If we did our survey again on Friday, how likely is it that our graph would be the same?

Roughly, what is 51 times 47?

How many crosses in the next diagram? + ++ +++
And the next?

Designing and comparing procedures

How might we count this pile of sticks?

How could you subtract 37 from 82?

How could we test a number to see if it is divisible by 6?

How could we find the 20th triangular number?

Are there other ways of doing it?

Interpreting results

So what does that tell us about numbers that end in 5 or 0?

What does the graph tell us about the most common shoe size?

So what can we say about the sum of the angles in a triangle?

Applying reasoning

The seven coins in my purse total 23p. What could they be?

In how many different ways can four children sit at a round table?

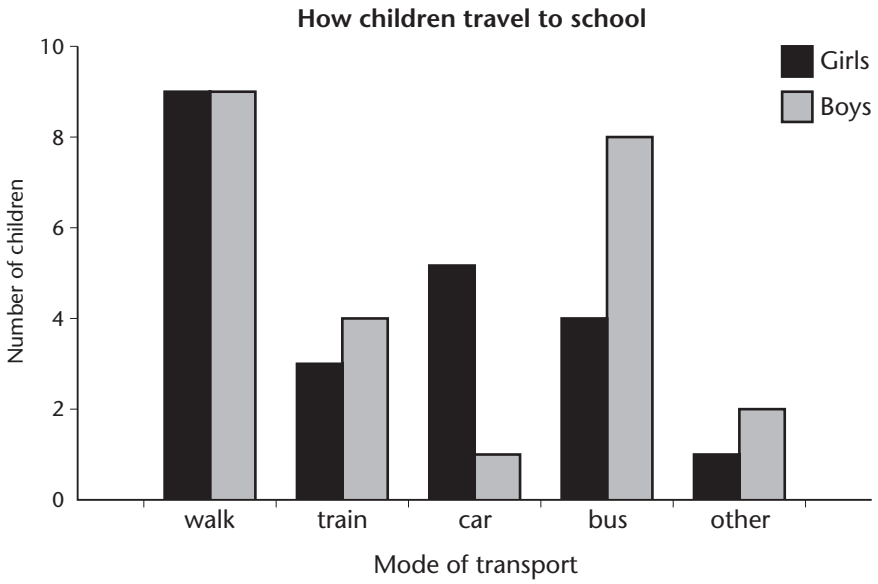
Why is the sum of two odd numbers always even?

This classification and the examples are taken from the National Numeracy Strategy guide *Mathematical vocabulary*, which you can download from:

www.standards.dfes.gov.uk/numeracy/publications/resources/vocabulary/MathematicalVocabulary.pdf

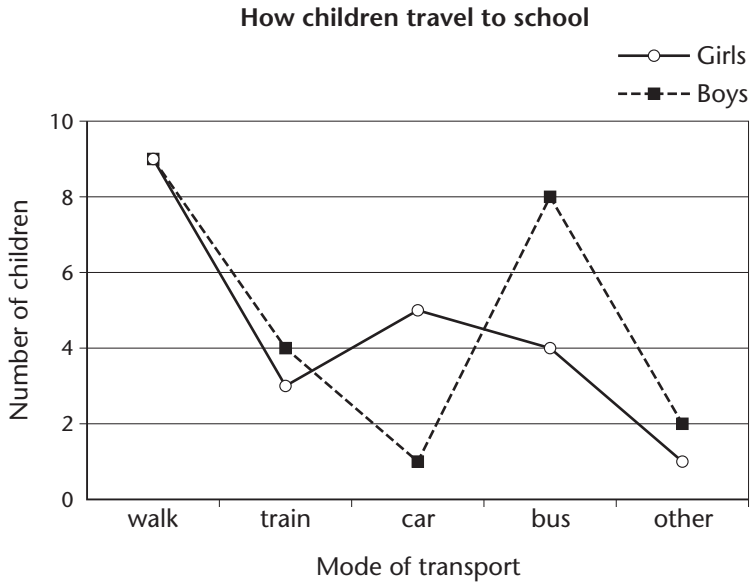
Resource 10f How children travel to school

The chart below represents how a group of children travel to school. Imagine that you have shown this graph to a Year 7 class.



Use this space to suggest questions that will establish how well pupils can interpret this type of graph.

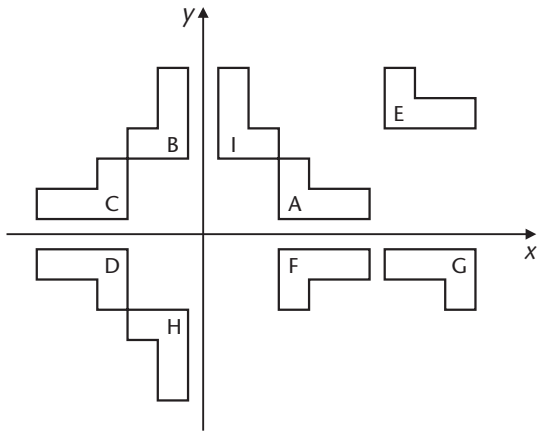
This is another way of representing the same data.



Use this space to suggest questions that would encourage pupils to compare the relative usefulness of the two graphs.

Resource 10g Transformations

Assume that the diagram below is provided as part of your department's resources for a Year 9 unit of work on transformations. The unit includes the objective: 'recognise and visualise transformations and symmetries of 2-D shapes'.



Assume that pupils are coming towards the end of the unit. You want to use the diagram to assess both how well the pupils understand the different transformations they have met and how well they can use the associated mathematical terms.

Use the space below to jot down some probing questions designed to encourage discussion among pupils in groups. The questions should help you to listen in and assess pupils' understanding and use of language.

Resource 10h Plan for a plenary

Plan a plenary designed to confirm what Year 9 pupils have learned about transformations and to reveal any remaining misconceptions.

Plenary organisation and activity

Examples of probing questions to use in the plenary

Key points for pupils to remember to be drawn out at end of plenary

Resource 10i Summary and further action on Module 10

Look back over the notes you have made during this module. Identify the most important things to consider and modify in your planning and teaching of oral and mental work.

List two or three key points that you have learned.

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List two or three points to follow up in further study.

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List two or three modifications that you will make to your planning or teaching of oral and mental work.

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List the most important points that you want to discuss with your head of department, or any further actions you will take as a result of completing this module.

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