Closing the word gap: mathematics

Section 1: Vocabulary for your subject

Maria Howard has taught mathematics for over 10 years. Currently a curriculum lead, she has also led on numeracy within her school and local authority. She has written about the importance of mathematical vocabulary in the classroom and has developed teaching resources to support students’ mathematical communication.

She shares her practical classroom ideas for closing the word gap with strategies to develop students’ understanding of the words we read, hear, and speak.

Using word banks

Advice for teachers

Mathematics has a wealth of words that students are unlikely to meet in other curriculum areas, alongside words used in other curriculum areas which have different meanings. It is an easy assumption to think that it is more important to give students the skills to solve problems numerically or algebraically than to develop their mathematical vocabulary. However, by doing this we simply widen the word gap. We also limit students’ ability to think, talk, and act like mathematicians in our classrooms.

Word banks are useful in grouping key words or phrases together for a specific topic or skill. When students understand the topic key words, they are more likely to be able to access questions relating to that topic and to explain their answers.

When choosing words for a word bank, target the most important in terms of understanding and talking about mathematics. Which words do students need to be able to understand to access assessments? Which words need to be specifically taught to clarify misconceptions? Which words don’t need to be included (for example, in teaching arithmetic to most students, you could probably leave out the words add and subtract)?

<table>
<thead>
<tr>
<th>Arithmetic</th>
<th>Circle geometry</th>
<th>Bar charts</th>
<th>Comparing numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>difference</td>
<td>centre</td>
<td>axis</td>
<td>ascending</td>
</tr>
<tr>
<td>multiply</td>
<td>chord</td>
<td>data collection sheet</td>
<td>descending</td>
</tr>
<tr>
<td>product</td>
<td>circumference</td>
<td>frequency</td>
<td>equal</td>
</tr>
<tr>
<td>sum</td>
<td>diameter</td>
<td>frequency diagram</td>
<td>equivalent</td>
</tr>
<tr>
<td>total</td>
<td>radius</td>
<td>tally</td>
<td>inequality</td>
</tr>
</tbody>
</table>
Suggested strategies for using word banks

- **Peer quiz.** Challenge students to write questions for each other using words from their word bank.
- **Use the words.** Ask students to repeat back words from word banks to you and then to put them in sentences to answer questions.
- **Frayer diagrams.** Get students to put their vocabulary in a mathematical version of a Frayer diagram. This is a type of graphic organiser and could be organised as shown below. Related words can be referenced within this.

<table>
<thead>
<tr>
<th>Definition</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 2D shape which has only straight sides.</td>
<td>What is the exterior angle of a regular 8-sided <strong>polygon</strong>?</td>
</tr>
<tr>
<td>Answer: Exterior angles sum to 360°. 360 ÷ 8 = 45°</td>
<td><strong>Regular:</strong> all angles are equal.</td>
</tr>
</tbody>
</table>

**Examples/diagrams**

**Non-examples**

---

**Independent learning tasks**

- **Revise the meaning.** Set a homework task where students learn the meaning of each word from a word bank. Give examples rather than definitions where appropriate. You are testing the understanding of the words rather than students' mathematical processing skills, hence the simple arithmetic used in the examples below.

Learn the meaning of the words below.

<table>
<thead>
<tr>
<th>Word</th>
<th>Example and practice questions</th>
</tr>
</thead>
</table>
| **product** | What is the *product* of 5 and 3? 5 × 3 = 15  
What is the *product* of 6 and 2?  
What is the *product* of 10 and 7? |
| **sum** | What is the *sum* of 5 and 3? 5 + 3 = 8  
What is the *sum* of 6 and 2?  
What is the *sum* of 10 and 7? |
| **difference** | What is the *difference* between 5 and 3? 5 – 3 = 2  
What is the *difference* between 6 and 2?  
What is the *difference* between 10 and 7? |
| **total** | Calculate the *total* of 10, 2, and 9. 10 + 2 + 9 = 21  
What is the *total* of £1, £3 and £5?  
What is the *total* of 5m, 2m and 4m? |
| **multiply** | Multiply 4 and 2. 4 × 2 = 8  
Multiply 9 and 3.  
Multiply 12 and 11. |
Mathematical dictionary. Get students to create their own mathematical dictionary which they add to each week to compile a reference tool both for use in class and for revision. I like to give them the option to use an example or a diagram.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Word</th>
<th>Definition/Examples/Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circle theorems</td>
<td>tangent</td>
<td>A line that just touches the circumference of a circle.</td>
</tr>
<tr>
<td>Factors and multiples</td>
<td>factor</td>
<td>The factors of 12 are 1, 12, 2, 6, 3, and 4 because:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$1 \times 12 = 12$, $2 \times 6 = 12$ and $3 \times 4 = 12$</td>
</tr>
</tbody>
</table>

Vocabulary journal. Challenge students to find ways to use their mathematical vocabulary in other subject areas. Help students to choose the words carefully so that this is done in a meaningful way. Students can then record when and how they use each word.

<table>
<thead>
<tr>
<th>Word</th>
<th>Subject</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>calculate</td>
<td>science (physics)</td>
<td>I calculated the speed of a model car travelling down a ramp.</td>
</tr>
<tr>
<td>increase</td>
<td>geography</td>
<td>I studied the population increases in India and China in the last century.</td>
</tr>
</tbody>
</table>

Making links between key terms

Advice for teachers

The same word in mathematics is often used across different topics. Understanding how and when a specific word can be used allows a student to make links across topics and deepens a student’s understanding.

Show students how words within a topic relate to each other, for example, the word angle:
<table>
<thead>
<tr>
<th>Word</th>
<th>Related adjectives</th>
<th>Definition/Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Angle</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Size of angles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>acute</td>
<td>less than 90°</td>
<td><img src="image" alt="Acute Angle" /></td>
</tr>
<tr>
<td>obtuse</td>
<td>between 90° and 180°</td>
<td><img src="image" alt="Obtuse Angle" /></td>
</tr>
<tr>
<td>reflex</td>
<td>between 180° and 360°</td>
<td><img src="image" alt="Reflex Angle" /></td>
</tr>
<tr>
<td>right</td>
<td>exactly 90°</td>
<td><img src="image" alt="Right Angle" /></td>
</tr>
<tr>
<td><strong>Triangles</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>base</td>
<td>(\text{base}) angles in isosceles triangle are equal</td>
<td><img src="image" alt="Isosceles Triangle" /></td>
</tr>
<tr>
<td><strong>Angles in parallel lines</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>alternate</td>
<td>(\text{alternate}) angles are equal</td>
<td><img src="image" alt="Alternate Angles" /></td>
</tr>
<tr>
<td>corresponding</td>
<td>(\text{corresponding}) angles are equal</td>
<td><img src="image" alt="Corresponding Angles" /></td>
</tr>
<tr>
<td><strong>Angles in polygons</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>interior</td>
<td>the angle on the inside of a shape</td>
<td><img src="image" alt="Polygon Interior Angle" /></td>
</tr>
<tr>
<td>exterior</td>
<td>(\text{exterior}) angles sum to 360°, interior angle + (\text{exterior}) angle = 180°</td>
<td><img src="image" alt="Polygon Exterior Angle" /></td>
</tr>
</tbody>
</table>
Suggested strategies for making links

- **Learning maps.** When reviewing and revising, create learning maps that show how a word can be used in different topics. For example:

  ![Learning maps example]

  **Labelling parts of a circle**
  Diameter = \(2 \times \text{radius}\)

  **Area of a circle**
  Area of a circle = \(\pi \times \text{radius}^2\)

  **Circle theorems**
  Tangent meets the radius at 90°

  **Volume of a cylinder**
  Volume of a cylinder = \(\pi \times \text{radius}^2 \times \text{length}\)

- **Adjectives.** Get students to identify the adjectives that can be used to describe a particular mathematical word. For example, *gradient* can be described as *positive*, *negative*, *steep*, *increasing*, *decreasing*, *constant*, and *variable*. Students could then produce diagrams demonstrating the different gradients.

- **Bingo.** Play a version of Bingo where you give students grids with words on and you read out words relating to those words. For example, if you read out the word *quadrilateral*, students could cross off *parallelogram*, and if you read out the word *segment*, students could cross off the word *circle*.

**Independent learning tasks**

- **Use the terms in questions.** Challenge students to create as many different types of question as they can using a particular word. For example, *perimeter* can be used in questions involving converting metric units, collecting like terms, forming and solving equations, and scale factors.

- **Research.** Get students to research the development of a particular area of mathematics and its associated vocabulary.

**Exploring etymology and morphology**

**Advice for teachers**

The root words that are used in mathematical vocabulary are not something that many classes explore in depth. Giving students the tools to decode new words can be extremely powerful.

Focus initially on root words that students will come across most frequently.
<table>
<thead>
<tr>
<th>Root word</th>
<th>Meaning</th>
<th>Examples</th>
</tr>
</thead>
</table>
| centi     | a hundred | centimetre (one hundredth of a metre)  
centilitre (one hundredth of a litre)  
century (one hundred years)  
per cent (parts out of one hundred) |
| equa/i    | equal, the same | equivalent (the same)  
equals (is the same as)  
equidistant (the same distance apart)  
equation (a statement showing two things that are the same)  
equilateral triangle (a triangle with three equal angles) |
| kilo      | a thousand | kilometre (a thousand metres)  
kilogram (a thousand grams) |
| gon       | angle | decagon (a 2D shape with 10 angles/sides)  
diagonal (a slanted line running across a space)  
octagon (a 2D shape with eight angles/sides) |
| quadr/a/i | four | quadrant (one of four equal parts)  
quadrilateral (a 2D shape with four straight sides) |

**Suggested strategies for teaching etymology and morphology**

- **Flash cards.** Once students have got the idea of looking for root words within mathematics, help them to break down particular words into their parts and explore examples using those words. One way to do this could be by making flash cards for different words.

  - **Bisect**

    | bi: two | sect: cut |
    |---------|-----------|
    | **bisect**: to cut something into two equal parts |

    ![Bisect Diagram](image)

    A line dividing an angle into two equal parts.  
A line at right angles to another, dividing it into two equal parts.

- **Decode the meaning.** Provide students with a bank of root words and their meanings, and then ask them to decode what different words could mean.

- **Draw attention to the roots.** When listing and explaining key words during a lesson, underline and explore any root words. Students can add this information to their own word banks and glossaries.
Independent learning tasks

- **Root word investigations.** Students could be asked to find as many mathematical words as possible containing a specific root word, for example, *vert/a/e* meaning turn.

- **Latin or Greek?** Students could research which languages provide different root words in mathematics and present their findings. Root words relating to numbers are particularly interesting.

Using talk to widen vocabulary

Advice for teachers

I have had the privilege of observing a lot of very talented mathematics teachers over the years, each with their own strengths and unique teaching style. However, one key area of professional development we all share is that we need to encourage (and support) our students to talk about mathematics in full sentences. Far too often we do all the mathematical communication for students ourselves. Look at the following example:

Teacher: What do we know about the exterior angles in a regular polygon? Amina?
Amina: They're equal.
Teacher: And what must they add up to? Chantal?
Chantal: 360.
Teacher: And how many exterior angles are there in an octagon? Marianna?
Marianna: Eight.
Teacher: So, what would we do to work out one of the exterior angles? George?
George: 360 divided by 8.
Teacher: Good. Beth, can you work that out?
Beth: 45.

In this example, I have used questioning effectively. I have targeted it at individual students and have involved my class in the process of explaining the example in clear steps. Alongside this, I have modelled the mathematics for students to copy down from the board. However, I have not allowed my students to communicate like mathematicians, I have not asked them to respond in full sentences, and I have not given them opportunities to practise using the subject-specific vocabulary themselves.

Here is an alternative dialogue:

Teacher: This question is asking us to find one of the exterior angles in a regular octagon. Amina, could you explain how you could work that out?
Amina: 360 divided by 8 is 45.
Teacher: Could you put that in a sentence for me? You can use one of the sentence structures on the wall.
Amina: I think the answer is 45 because 360 divided by 8 is 45.
Teacher: I like how you’ve explained your working out. Could you improve your answer by giving me some reasons why you did that calculation?
Amina: Er … no. I’m not sure.
Teacher: George, could you give me some reasons?
George: A regular shape has equal angles, and we know that the exterior angles of any polygon sum to 360. So to get the exterior angle of a regular octagon, we divide 360 by 8 because an octagon has eight exterior angles.
Teacher: Thanks, George. Fantastic use of mathematical vocabulary. Amina, could you now give your answer again including some reasons?

At times it may not be practical or relevant to go into mathematical explanations to this degree. However, it is important that all students get the opportunity to communicate mathematically within the classroom and to develop their ability to do this over time.

Suggested strategies for using talk

- **Taboo.** Play Taboo with key vocabulary: give a student a card with a word on that they must describe to the class, with a list of banned words below it. The rest of the class guesses the word. An alternative is to have a student face the class with their back to the board while the class tries to get the student to guess the word projected behind them.

<table>
<thead>
<tr>
<th>Key word: quadrilateral</th>
<th>Key word: gradient</th>
<th>Key word: difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banned words:</td>
<td>Banned words:</td>
<td>Banned words:</td>
</tr>
<tr>
<td>four</td>
<td>m</td>
<td>take away</td>
</tr>
<tr>
<td>quad</td>
<td>divide</td>
<td>subtract</td>
</tr>
<tr>
<td>shape</td>
<td>over</td>
<td>minus</td>
</tr>
<tr>
<td>straight</td>
<td>graph</td>
<td></td>
</tr>
</tbody>
</table>

- **Rehearsals.** For mathematical words that are difficult to pronounce, get students to repeat them back to you three times. Although this may initially feel awkward, classes soon get used to it.

- **Written explanations.** Where written explanations are required, give students plenty of practice, and insist on students doing this correctly. When feeding back on questions which require full explanations, highlight when students haven’t done so, and avoid the temptation to give full marks.

- **Celebrate explanations.** Celebrate great mathematical explanations in class, and give students recognition for good oracy within mathematics lessons.

- **Displays.** Give students clear sentence starters for mathematical explanations, and insist on them using these at specific points. The sentence starters can be displayed on walls for quick reference.

```
To get the answer, I first ... [state working out]
because ... [give reason]
then I ... [state working out]
because ... [give reason]
```

**Independent learning tasks**

- **Peer mentoring.** Set up peer mentoring for older students to support younger students with their mathematics. Under-performing students at GCSE could practise explaining concepts to weaker students in year 7 or 8, and potentially also build their confidence and resilience.

- **Take it home.** Set homework tasks which require students to provide reasons and working out for all their answers, and give students opportunities to improve their work as needed. Challenge students to teach someone at home something they have learned in class, giving mathematical explanations.
Avoiding common mistakes and misunderstandings

Advice for teachers

Word meanings can vary across subjects. A line of best fit through a scatter graph is assumed to be a straight line in mathematics at GCSE; however, it is often a curve in science. An average could be the mean, median, or mode in mathematics, whereas in other subjects it usually refers only to the mean. Addressing misconceptions early on can reduce the chances of errors becoming embedded in a student’s understanding of a word.

Words that sound similar can also give students a false sense of confidence with new vocabulary. I have had students confuse correlation with coronation, not to mention the student who confidently replied, ‘Oh yeah, proportion, like in a proportion of rice.’

Suggested strategies for correcting these mistakes and misunderstandings

- **Keep track.** Keep a record of misconceptions and errors made by students. Ever since my student confused proportion with portion, I have explicitly taught the pronunciation and spelling of the word.
- **Muddled words.** There are some topics where words are often confused, so you could give students a correction activity including answers accompanied by incorrect reasons. For example, when describing angles in parallel lines:

  ![Diagram](https://via.placeholder.com/150)

  \[ z = 120^\circ \text{ because corresponding angles are equal} \]

- **Alternate**

  \[ z = 120^\circ \text{ because corresponding angles are equal} \]

  Independent learning tasks

- **Keep a record.** Ask students to record any words they have misunderstood. Get them to make flash cards and test themselves on the correct meanings.
- **Compare with other subject areas.** Challenge students to find words used in mathematics that have a completely different meaning, or a similar but subtly different meaning (line of best fit), in another curriculum area. Get them to create posters explaining the different meanings of the word.

Understanding vocabulary for exams/assessments

Advice for teachers

After assessments, I have often spoken to colleagues who have been frustrated that students hadn’t been able to answer a question correctly because they couldn’t understand what the question was asking them, yet very few teachers explicitly teach their students the language of exams and assessments. While we may drill our students in the difference between a factor and a multiple, how many of us teach command words such as express, state, and calculate?

The language of assessments is most effectively taught when a consistent whole-school approach is applied. There are clear differences between evaluate in a mathematical and a literary context, and students need to be made aware of these.
Specialist word bank

Refer to the command words below from your specific exam board, and see the associated definitions online for AQA and Edexcel. The lists themselves are not exhaustive, but these are words specifically highlighted by the exam boards.

Please note that OCR and WJEC Eduqas do not have command words specifically highlighted for their GCSE Mathematics qualifications.

<table>
<thead>
<tr>
<th>Command words used in GCSE Mathematics exams</th>
<th>AQA</th>
<th>Edexcel</th>
</tr>
</thead>
<tbody>
<tr>
<td>assess</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>calculate</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>comment*</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>complete</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>describe</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>draw</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>estimate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>expand</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>explain*</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>factorise</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>find</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>give / give reasons*</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>justify</td>
<td></td>
<td></td>
</tr>
<tr>
<td>measure</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>multiply</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>plot</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>prove</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>rotate</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>shade</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>show*</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>simplify</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>sketch</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>solve</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>translate</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>work out</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>write / write down</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

*Words identified in recent examiner reports as posing difficulties for students.

All four exam boards only specifically reference mathematical vocabulary in their specifications in two areas: the language of algebra and the language of factors and multiples.

However, vocabulary specific to mathematics is relevant to every topic, and this can be found in the detail of the relevant specification.

Key areas of concern identified in examiner reports

Examiner reports specify many vocabulary errors and misconceptions, including errors in understanding mathematical symbols. In the Edexcel June 2018 report, the chief examiner even stated, ‘A lack of mathematical reasoning continues to prevent some students from gaining marks when explanations are required … centres are advised to practise these types of questions and the associated vocabulary’.

Some common misconceptions from the 2018 examiner reports include:

- confusing area and perimeter
- misunderstanding the term proportion
• misunderstanding the key term expression and instead giving an equation, a numerical answer, or an inequality
• confusing parts of the circle
• not knowing corresponding or alternate angles
• not understanding the term range.

Further detail is given in each board’s examiner report.

**Suggested strategies for teaching vocabulary for exams/assessments**

• **Highlight new words.** When going through assessments in class, get students to highlight any problematic words. Work through definitions and examples of these as a class, and create a specific exam word bank for each group that you teach.

• **Guess the command word.** Give students some questions with the command words missing. They could then guess the missing word and work out the answer. For example:

\[
2x - 3 = 4x + 9
\]

\[
\text{and } (x + 3)(x - 4)
\]

\[
25^{0.5}
\]

Here, the missing command words would be: solve, expand and simplify, and evaluate.

• **Broad terms.** Some words, when used in assessments, refer to a group of possible responses. These are worth specifically revising as a group of terms. For example, not understanding the term frequency diagram could lose four marks for a student, when they only needed to draw a bar chart to represent some data. You could get students to create flash cards, with accompanying exam style questions alongside these.

**Frequency diagrams: examples**

<table>
<thead>
<tr>
<th>Pie chart</th>
<th>Pictogram</th>
<th>Histogram</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="https://example.com" alt="Pie chart" /></td>
<td><img src="https://example.com" alt="Pictogram" /></td>
<td><img src="https://example.com" alt="Histogram" /></td>
</tr>
</tbody>
</table>

- **Pie chart**
- **Pictogram**
- **Histogram**

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Explore question types. Give your students a variety of questions on a given topic, and get them to sort them according to what they are being asked to do. For example, the Teachit Maths resource The language of ratio (18855) includes cards which give a variety of ratio questions on creating/simplifying ratios, using a ratio to find one quantity when others are known, and dividing quantities in a given ratio.

Make links. Ask students to group exam command words. For example, they could group algebraic key words.

### Independent learning tasks

- **Exam vocabulary.** Get students to write out mathematics questions on a recent topic using appropriate terminology.
- **Record other uses.** Challenge students to record questions from other subject areas which use the same command words in assessments. Ask them to compare and contrast their uses so that they answer questions in an appropriate way for each subject area.
Section 2: Strategies to further develop students’ vocabulary

Here are Maria Howard’s suggestions for effective classroom strategies to develop students’ ability and confidence in using key vocabulary.

1. Assessing understanding of key words

I have often been surprised at how words I had assumed to be in a student’s vocabulary are in fact not, and so create stumbling blocks for them in mathematical conversations. At my last school I was curious about students’ vocabulary awareness, so I thought about ways to assess their knowledge of mathematical vocabulary independently from their ability to solve mathematical problems.

Assessment for learning

Assessment for learning strategies during lessons provide one approach. You could ask students to draw or write on their mini whiteboards images, diagrams, or phrases that show their understanding of key words. Examples include:

- an image of a protractor
- a diagram showing an acute angle
- a word or phrase that means the same as find the product of
- an equation*
- an expression*
- a number to the power 2*
- three numbers in ascending order*
- a prime number*.

* For these you could challenge the class to have no two mini whiteboards showing the same.

You can also set a challenge to find non-examples, such as:

- a number that isn’t a square number
- a shape that isn’t a polygon.

Formative assessment

At times I have felt that more formative assessment would be useful and have developed some written tests for knowledge of vocabulary. While these are straightforward to produce, it can be challenging to make sure you are testing for the understanding of a word rather than for the mathematical knowledge and skills.

Here is a possible example for algebraic commands. Students are not answering any of the questions, but simply connecting the words with the mathematical processes.
Algebra command words: check your vocabulary

Choose the correct word from the word bank for each of the questions below.

<table>
<thead>
<tr>
<th>solve</th>
<th>expand</th>
<th>factorise</th>
<th>substitute</th>
<th>simplify</th>
</tr>
</thead>
</table>

Q1: ___________ 5(x + 3)
A: 5x + 15

Q2: ___________ 4x = 12
A: x = 3

Q3: ___________ y = 3 into 4y + 2
A: (4 × 3) + 2 = 14

Q4: ___________ 5c + 2c + 4c
A: 11c

Q5: ___________ 5x + 15
A: 5(x + 3)

Answers: expand, solve, substitute, simplify, and factorise.

2. Practise using mathematical vocabulary

When working through a series of questions with my year 9 class, I checked my demand for students’ use of mathematical vocabulary. The first was as follows:

Calculate the perimeter of the following:

I asked a student for the perimeter of the first shape. He said ‘0.9’ I asked the student how he had worked it out, and he told me. I said, ‘Well done,’ and we moved on. I then realised that there was no expectation for using any mathematical vocabulary in these answers. I have spent a lot of time teaching the meaning of key words such as perimeter each lesson, but I have not required them to use the word. A better question would have been:
Our choice of wording determines the mathematical vocabulary required from students. The more our students practise using key words, the more confident they will become in their understanding, and the more quickly we can identify any misconceptions.

3. Talking like mathematicians

I find it very tempting to talk for my students. When students answer in full sentences and give correct mathematical explanations every time, it is time-consuming. It can feel as though it is at the expense of making progress in a lesson. However, from my classroom experience, those students who can talk about mathematics and communicate their thinking generally retain learning a lot better. They are also generally more successful at tackling problem-solving questions. By talking about the mathematics and explaining their thinking, they can apply that knowledge to new situations.

Lower-attaining students may need a lot of support and structure as they take their first steps in communicating as mathematicians. One way to do this is to give structured sentences for them to use.

For example, students could choose words to make a question for another student.

<table>
<thead>
<tr>
<th>Find</th>
<th>Calculate</th>
<th>the</th>
<th>product of</th>
<th>difference between</th>
<th>eighty</th>
<th>forty</th>
<th>two thousand</th>
<th>seventy</th>
<th>and</th>
<th>eighty</th>
<th>forty</th>
<th>two thousand</th>
<th>seventy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate</td>
<td>Work out</td>
<td>Evaluate</td>
<td>the</td>
<td>product of</td>
<td>difference between</td>
<td>sum of</td>
<td>total of</td>
<td>eighty</td>
<td>forty</td>
<td>two thousand</td>
<td>seventy</td>
<td>and</td>
<td>eighty</td>
</tr>
</tbody>
</table>

You could provide a similar frame for a response.

<table>
<thead>
<tr>
<th>The</th>
<th>product of</th>
<th>difference between</th>
<th>sum of</th>
<th>total of</th>
<th>eighty</th>
<th>forty</th>
<th>two thousand</th>
<th>seventy</th>
<th>and</th>
<th>eighty</th>
<th>forty</th>
<th>two thousand</th>
<th>seventy</th>
</tr>
</thead>
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<td>The</td>
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<td>sum of</td>
<td>total of</td>
<td>eighty</td>
<td>forty</td>
<td>two thousand</td>
<td>seventy</td>
<td>and</td>
<td>eighty</td>
<td>forty</td>
<td>two thousand</td>
<td>seventy</td>
</tr>
</tbody>
</table>

Once modelled by the teacher, this could work as a paired activity to maximise the opportunities for mathematical communication.

Having posters on the walls with examples of explanatory sentence structures, specific to mathematics, can also be useful. Examples could include:
On Teachit Maths, there is a variety of posters which you could display to support students’ understanding of how to improve their language of explanation, such as Explaining in maths – mode (26908), Explaining in maths – best value for money (26909) and Explaining in maths – alternate angles (26910).

4. **Spelling of key words**

In my classes, I spot trends in the misspelling of key words. 2D shapes seem to be a particular stumbling block: words such as parallelogram and trapezium are often incorrect, even when copied directly from the board.

Some schools use marking codes for spelling. In my current school we use class feedback sheets where a section is devoted to SPaG so we can identify commonly misspelled words.

To establish effective ways of targeting common spelling errors, work with colleagues across the curriculum, including the English department. It is best practice to make use of students’ knowledge of word roots and words within words, and to create mnemonics for specific words in order to embed a rich understanding. It is also helpful to identify common patterns in the errors made, and to get students to work on groups of words together. Words with double letters, such as parallelogram, are one such category.

5. **Decoding questions in assessments**

I recently worked with colleagues to design an assessment for our year 8 students. It included some questions adapted from GCSE papers. We had given much time and thought to the level of difficulty, ensuring there was no untaught content. We felt we had done a really good job. During the assessment, several students looked perplexed and stopped working. The problem? The word ‘patio’. The question involved arranging square stones for a ‘patio’ in a rectangular shape. They wondered if a ‘patio’ was a mathematical shape they should know about.

While it would be almost impossible to pre-empt all the vocabulary that will come up for our students in assessments, we can certainly make sure they are taught the meaning of words that recur frequently. An easy way to do this is to make sure that these words form an integral part of our questioning and our lessons.

Take this series of questions. It uses different command words to make sure that students recognise the different ways a question could be asked.
Express \( x \) in terms of \( y \):
\[
y = 4x + 2
\]
Rearrange \( x \) in terms of \( y \):
\[
4y = x + 9
\]
Make \( x \) the subject of the formula:
\[
y = 12x + 3
\]

We can use strategies to help students to decode the meanings of questions, even if there are words within them that they don’t understand. Take the example question below.

A man invests £200 in an account with a simple interest rate of 5% per annum. How much money is in the account after 3 years?

There are several words which could present problems, including *invest* and *per annum*. However, students should be able to highlight the most important numerical information in the question. This is a form of skim reading, a skill used in other subjects to get a general understanding of a text. We simply need to train our young mathematicians to approach mathematical questions in a similar way.

A man invests £200 in an account with a simple interest rate of 5% per annum. How much money is in the account after 3 years?

By highlighting the key information in the text, the problem is simplified. This doesn’t guarantee that a student will go on to answer the question correctly, or even that one of the words they are unsure of won’t be critical in understanding the question, but it does increase their chance of tackling questions successfully when there are unfamiliar words.

### 6. Mathematical vocabulary outside the classroom

I like the idea of my students talking like mathematicians outside my classroom. Designing form time activities promoting the use of mathematical vocabulary is one way to do this. If you have mixed-attainment levels or even mixed-year groups in your form, it is an opportunity for all learners to share good examples of mathematical communication.

You could get students to describe something using specified key words. For example:

<table>
<thead>
<tr>
<th>Key words</th>
</tr>
</thead>
<tbody>
<tr>
<td>sides</td>
</tr>
<tr>
<td>vertices</td>
</tr>
<tr>
<td>edges</td>
</tr>
<tr>
<td>faces</td>
</tr>
</tbody>
</table>

Using at least two of the words above, describe a 2D or a 3D shape.

Can another student guess the shape?

You can use other mathematical words as well.

You will need to explain the activity and the meaning of words to tutors. In this activity, non-specialists may need reminding of the difference between a side and an edge. You may also need to differentiate to include options of labelled 2D and 3D shapes from which to choose.

### 7. Mathematical words in other subject areas

There are certain mathematical words that are used extensively in other subject areas. For example, the word *percentage* is used in geography, science, and business. The word *range* has a variety of meanings in science. For example, the *range* of measurements of a measuring instrument, the *range* of values on the axis of a graph, and the highest and lowest values of a set of data. In mathematics, to state the *range* is to state the difference.
Creating a whole-school numeracy document demonstrating mathematical vocabulary and its uses across a school, to include similarities and differences, gives teachers a useful reference tool. It allows them to highlight cross-curricular links when they are teaching and also allows them to draw on examples from other subject areas to support learning.

8. Mathematical words in other subject areas

I could definitely do more to celebrate great mathematical communication in my classroom. You can do this in the form of competitions, such as:

- Explanation of the week: great explanations are recorded throughout the week and voted on at the end.
- Key words of the week: students score points for their teams depending on how well they use key words during the week.

You can also just make a big deal of great explanations and communication as and when they happen, perhaps regularly adding students’ names to a roll of honour.
Lesson idea: Recalling circle theorems

Activity

The aim of this activity is to get students to use the correct mathematical vocabulary in recalling circle theorems to solve problems. Examiner reports have highlighted that explaining reasoning correctly is a key area of development for students. The activity is suitable after teaching circle theorems and could also be used for revision.

- Arrange students in groups of three. One student is the adjudicator while the other two play against each other. The aim is to win the available cards.
- The students playing against each other arrange the cards, face down, in front of them. The adjudicator holds a copy of the answer sheet, which features the correct circle theorems and key vocabulary.
- The first student selects a card. They state out loud the circle theorem or mathematical fact which could be used with the geometry shown. The adjudicator awards the card to the student provided they use all the appropriate key words in their response and they do not contradict themselves. If the card is won, the adjudicator reads out the exemplar response. If it is not won, the card is replaced, face down.
- The other student has a turn, and the students continue to take turns until all the cards have been claimed.

If neither student wins any one of the cards, the adjudicator can then give both students a hint. The first to say the correct theorem or mathematical fact then wins the card.

Teaching tips

- Recap the theorems at the start of the lesson to support students further.
- You could adapt or extend this activity for other mathematical reasoning connected to geometry, for example, angles in parallel lines or angles in polygons.

Topic: Circle theorems

Materials required: Set of cards per group of students, and an answer sheet per group of students.
Classroom resource: Recalling circle theorems
Recalling circle theorems: answer sheet

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>The tangent at any point on a circle is perpendicular to the radius at that point.</td>
<td>Tangents from an external point are equal in length.</td>
</tr>
<tr>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>Angles in the same segment are equal.</td>
<td>The angle in a semicircle is a right angle.</td>
</tr>
<tr>
<td>e</td>
<td>f</td>
</tr>
<tr>
<td>The angle subtended by an arc at the centre of a circle is twice the angle subtended at any point on the circumference.</td>
<td>Opposite angles of a cyclic quadrilateral add up to 180.</td>
</tr>
<tr>
<td>g</td>
<td>h</td>
</tr>
<tr>
<td>The perpendicular from the centre of a circle to a chord bisects the chord.</td>
<td>Alternate segment theorem.</td>
</tr>
</tbody>
</table>
Lesson idea:
The language of area and perimeter

Activity
This activity aims to give students practice at explicitly using the language of area and perimeter correctly. In assessments it is a common error to confuse area with perimeter in 2D shapes. This activity gives students deliberate practice at reading out statements relating to area and perimeter, along with recall of the mathematical reasoning used to solve problems where they are involved.

Give students a worksheet, and ask them to fill in the missing words for each of diagrams a to f, allowing for time for calculations.

Select individual students to read out their responses to particular questions using the starter sentence given on the worksheet, their suggested answer, and then an explanation sentence. Ensure students can refer to these sentences when they respond.

Teaching tips
- To increase the amount of deliberate practice, you could get students in pairs to take turns to read their responses to each other before going through the answers as a class.

- To increase the level of challenge once students are more confident with the language of their explanations, you can remove some of the sentence prompts, but insist that students use the key words area and perimeter.

- This activity could be adapted to highlight the difference between volume and surface area (another two terms sometimes confused with each other in assessments).

Topic: Area, perimeter, and volume
Materials required: One worksheet per student.
**Starter sentences:**
- The perimeter of a 2D shape is the distance around its boundary.
  
  OR

- The area of a 2D shape is the amount of space inside its boundary.

**Explanation sentences:**
- I know this because to calculate the perimeter you add together all the distances around the boundary and … [working out].

- I know this because to calculate the area of a rectangle I multiply the base by the height and … [working out].

- I know this because to calculate the area of a triangle I multiply the base by the height, halve it, and … [working out].

- I know this because to calculate the area of a trapezium I add together the parallel sides, multiply the total by the perpendicular distance between them, halve it, and … [working out].
Reference list

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