Closing the word gap:

activities for the classroom

Science

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Closing the word gap: science

Section 1: Vocabulary for your subject

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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

Without a fluent understanding of the language of science, students cannot decode the meaning of the ideas they are learning. Given the number of complex ideas encountered by students in the science classroom, strategies which boost students' vocabulary acquisition should be central to our teaching.

Communication in science relies on a vast technical vocabulary of science-specific words, scientific interpretations of everyday terms, and a number of complex logical connectives which are used to link ideas.

Word banks

Scientific terms can be organised into a taxonomy of increasing abstractness (Wellington & Osbourne, 2001).

Level	Examples
Naming words • familiar objects, new names • new objects, new names • names of chemical elements • other nomenclature	Bunsen burner conical flask ethene gauze helium hydrogen meniscus oesophagus trachea
Process words • capable of ostensive definition • not capable of ostensive definition	combustion distillation evolution photosynthesis

Concept words • derived empirically • with everyday and scientific meanings • theoretical constructs	atom electron element field force mole pressure temperature

One way to categorise vocabulary in science is:

- terms with one meaning, which add **breadth** to a student's vocabulary (new to a student)
- terms with two or more meanings, which add **depth** to a student's vocabulary (not new to a student, but which have a different meaning in a scientific context).

	Terms which add breadth	Terms which add depth
Non-technical	adjacent analyse appropriate directly proportional estimate limit linear maximum obtain sufficient	agent dependent effect rate standard transfer volume
Semi-technical	component continuous excess particle probability proportion random repel	excite fair incident key material negative property static
Scientific	convection diode exothermic gene ion molecule proton respiration	conduct conductor cracking elastic equation friction potential power precipitation weight

We need to give extra attention to scientific terms which have everyday meanings as well (in the bottom right-hand box), to clarify to students our implied scientific meaning.

When using word banks with students in a lesson, break down the vocabulary for a specific lesson or topic into manageable sections. For example, the target language for a chemistry lesson on making salts might look like this:

Apparatus	Technique	Observations
Bunsen burner conical flask evaporating basin filter funnel filter paper glass rod	crystallisation filtration	clear colourless disappear effervescence excess filtrate residue solution

Suggested strategies for using word banks

- **Topic vocabulary.** Provide students with a framework for the vocabulary for the topic, and ask students to use their knowledge of the definitions to organise the vocabulary into the word bank.
- **Words which add depth.** For words which students know, but not in a scientific context (words which add depth), provide the definitions in other contexts, and ask students to suggest links between the concepts which help to explain why the same word is used.
- **Pictionary.** Play Pictionary with teams of students, using vocabulary from the word bank.

Independent learning tasks

- **Keeping a journal.** Get students to log their use of words which have meanings in other contexts and which they have encountered in the science classroom. For instance, if you are teaching salts in a chemistry lesson, ask students to make a note when they use words such as *solution* outside the classroom.

Making links between key terms

Advice for teachers

Scientific ideas are generally linked by logical connectives, such as *because* or *despite*. These words are common in scientific texts as well as in teacher talk and other contexts in school, but they can be very difficult for students to interpret.

Provide students with logical connectives in order of increasing difficulty (from left to right). For example:

because however	consequently despite hence in order to nevertheless similarly thus	essentially in practice in spite of respectively with respect to	conversely in accordance with moreover

Familiarising students with the full range of connectives is an important aim in building literacy in science. Many of the logical connectives above can be used interchangeably, and so you can build students' vocabulary by using synonyms and antonyms for logical connectives where these terms are unfamiliar.

Making links between key terms in science is critical. Concept terms cannot be understood in isolation: *acid* has no independent meaning; understanding the term *power* relies on understanding the terms *work* and *energy*; and the terms *element, atom, molecule, compound,* and *mixture* have complex logical connections.

Encourage students to make links between terms using their own words so that they can make sense of the overarching concepts.

Suggested strategies for making links between key terms

- **Concept maps.** Provide students with incomplete concept maps, and ask students to complete; this might be labelling the links or using the links to identify missing key terms. Alternatively, ask students to spot mistakes on a concept map and redraw a correct version. You could use the Teachit Science resource Keyword links template (30485).
- **The association game.** Play the association game in class. Each student is given a key term, and then the next student has to identify an associated term and the link.
- **Adding connectives.** Use word completion tasks with students where they select the correct logical connective for a sentence to make sense.
- **Venn diagrams.** Ask students to organise words or diagrams into Venn diagrams labelled with concept words which link together. For example, methods of increasing rate of reaction can be organised into those which increase the rate of collisions and those which increase the proportion of collisions which are successful ('increasing the temperature' would go in the overlapping area).

Independent learning tasks

- **Categories.** Provide students with a range of key terms on cards to organise into various categories. You could set the categories or allow students to create their own. As an extension of this task, get students to use the same terms, but instead make a link between two selected words.

Exploring etymology and morphology

Advice for teachers

Many words in science are built up from common root words. By breaking down key terms into their constituent parts, students build up an understanding of the root words. This helps them to decode terms they haven't met before, which is particularly important in assessments.

Many of these root words are common to other subjects, such as *bio*, which students may meet in English as a root in *biography* or in geography in *biodiversity*.

Root word	Meaning	Examples
an	without	anaemic, anhydrous
bio	life	biodegrade, biofuel
chrom/a/ato/o	colour	chromatography, monochrome
derm	skin	dermatitis
electr/i/o	electricity	electromotive, electroplating
end/o	inner	endocrine, endothermic
epi	on, upon, over	epidermis
exo	out, outside	exothermic, exoskeleton
haem/a/ato/o	blood	haemoglobin, haemophilia
hypo	under	hypothermia
iso	equal	isotope, isomer
lys/i/is/io	loosening, breaking down	analysis, electrolysis
mer	part	monomer, polymer
meter	measure	barometer, ammeter
stas/i/is	standing	homeostasis, haemostasis
therm/o	heat	thermometer, thermochromic

Common prefixes are also useful.

de-	removal, not/undo	delocalised, denature
inter-	between	intermolecular

Students should be encouraged to link root words across disciplines, such as *isosceles* when introducing *isomer*, or the difference between *internet* and *intranet* when learning the difference between *intermolecular* forces and *intramolecular* forces, to build their understanding of the words and their underlying concepts.

When relevant, it can be beneficial for students to understand the origin of the term to develop their understanding of the concept it represents. For example, *empirical* is derived from the Greek word *empeirikos*, which means 'derived from experiment'. Discussing why this term is used to identify empirical formulae can help students to understand the link between empirical and molecular formulae.

Suggested strategies for teaching etymology and morphology

- **Shared roots.** Model how to break down words in lessons, and ask students to think of other words which contain the same roots to make conceptual links.
- **Predictions.** Ask students to predict the meaning of a new word by identifying the meanings of the root words it contains.
- **Work it out.** Allow students to practise decoding terms they are unfamiliar with and suggesting plausible meanings.

Independent learning tasks

- **Root word glossary.** Get students to keep a list of root words with their meanings at the back of their books and to list any new words which include these.

Using talk to widen vocabulary

Advice for teachers

It is critical for students to be familiar with using the key terms in their own talk. This builds familiarity, but also provides you with opportunities to correct misuse of key terms on a regular basis.

When students explain their ideas, they are more likely to remember the content, as well as new vocabulary.

Students' progression in scientific talk can be characterised as follows:

	From ...	To ...
Responses	simple answers to closed questions	complex answers to open questions which expose their scientific reasoning
Speaking	discussion in pairs or small groups short contribution	presenting to a large audience sustained speaking
Vocabulary	use of everyday terms	fluent use of specialist scientific terminology
Language	use of familiar language patterns	selection of register and expression to suit the situation
Narrative	descriptive	analytic and evaluative

Suggested strategies for using talk to widen vocabulary

- **Model talk.** Use terminology in your talk to familiarise students with the terms and the range of situations in which they can be used. This also sets expectations about how students can raise the standard of their talk in science.
- **Synonyms and antonyms.** Use synonyms and antonyms of key words in your talk to help students to identify the meanings of words they are less familiar with.
- **Sound it out.** Model how to sound out difficult words like *phenolphthalein*, breaking them down into syllables, *phe-nol-phtha-lein*, and then say the word together so that all students pronounce the term out loud.
- **Just a Minute.** Play Just a Minute with vocabulary from the topic word bank without students using the word or repeating themselves. Other students can guess the word being described, or they can 'buzz in' if the speaker falters to finish the time and collect the points.
- **Challenge the language.** Challenge the use of vague language in students' answers. Encourage them to rephrase their responses using target language and appropriate register (full sentences).
- **Think, pair, share.** Use 'think, pair, share' so students can plan their answer to an open question using appropriate vocabulary and expression before presenting their ideas to the class.
- **Prepared speeches**. Allow opportunities for students to speak continuously on a topic, linking their ideas. This might be in a debate scenario, with students writing and preparing speeches, or a forensic science

practical, with students giving evidence to the 'jury' and ensuring they define key terms.

Independent learning tasks

- **Be the expert.** Ask students to teach each other using at least three key terms from the lesson. This works well as a plenary or as the following starter to recap learning from a previous lesson. Alternatively, ask specific students to prepare a summary of a lesson using a set list of key terms. Get these students to prepare thoroughly so that they are ready to explain terms to the rest of the class or to small groups.

Avoiding common mistakes and misunderstandings

Advice for teachers

Numerous key terms in science cause confusion for students. Some examples are given below, but it is worth keeping a list of commonly misused terms on display in your department.

Biology	Chemistry	Physics
confusing *evolution* and *natural selection* measuring the *amount* of a liquid instead of the *volume*	calling a liquid *clear* when it is *colourless* observing a substance *dissolving* instead of *disappearing*	confusing *velocity* and *speed* confusing *mass* and *weight* using *refraction, reflection*, and *diffraction* incorrectly

Suggested strategies for correcting these mistakes and misunderstandings

- **Share definitions.** Explicitly tackle common mistakes in class by clarifying the difference in meaning.
- **Fill the gaps.** Use word completion tasks in which students choose the correct term from a given list to suit the context. For example, copper sulfate solution is *clear*, but bromine water turns from brown to *colourless* in the presence of an alkene.
- **Spot the mistakes.** Provide students with a fake student answer which contains incorrect use of terminology. Ask students to spot the mistakes and correct these. Extend students' understanding by asking them to give feedback to the student, explaining why each of their errors changed the meaning.

Independent learning tasks

- **Peer feedback.** Identify specific common mistakes or misunderstandings in your class. Following explicit teaching to correct these, encourage peer feedback in class. You can 'snowball' this activity from pairs to fours and get students to choose the best uses of these previously misunderstood terms.

Understanding vocabulary for exams/assessments

Advice for teachers

Understanding the vocabulary for examinations presents a significant barrier to many students taking sciences at KS3 and GCSE. Students need to become familiar with these terms and feel confident interpreting questions in assessments so that they can demonstrate their knowledge and understanding effectively in their answers.

These terms can be divided into:

- command words
- scientific terms.

Specialist word bank

Command words used in GCSE Science exams	AQA	Edexcel	OCR	WJEC Eduqas
account for				✓
add		✓		✓
analyse			✓	
assess		✓		
calculate	✓	✓	✓	✓
check				✓
choose	✓		✓	✓
classify			✓	
comment on		✓		✓
compare	✓			✓
compare and contrast		✓	✓	
complete	✓	✓	✓	✓
conclude			✓	
construct			✓	✓
convert			✓	
deduce		✓	✓	
define	✓		✓	
describe	✓	✓	✓	✓
design	✓		✓	
determine	✓	✓	✓	✓
devise		✓		
discuss		✓	✓	✓
draw	✓	✓	✓	✓
estimate	✓	✓	✓	✓
evaluate	✓	✓	✓	
explain	✓	✓	✓	✓
give	✓	✓	✓	✓
give a reason		✓		✓
how			✓	✓
identify	✓	✓	✓	✓
illustrate			✓	
justify	✓	✓	✓	
label	✓	✓	✓	✓
measure	✓		✓	
name	✓	✓	✓	✓
outline			✓	
plan	✓		✓	
plot	✓	✓	✓	✓
predict	✓	✓	✓	
recall			✓	
select			✓	✓
show / show that	✓	✓	✓	✓
sketch	✓	✓	✓	✓
state		✓	✓	✓
state and explain		✓		
suggest	✓	✓	✓	✓
use/using	✓		✓	
what			✓	✓
which			✓	✓
why			✓	
write / write down	✓	✓	✓	✓

Key areas of concern identified in examiner reports

Recent examiner reports have identified a number of common areas of concern, such as students not using the correct command word (*describing* instead of *explaining*) and missing a particular word from the question, which either changes the meaning so students answer the 'wrong' question or narrows the question so students' answers are too general. Students are also prone to misreading a word in the question, for example, giving a *name* for a compound instead of the *formula* that was asked for.

A number of other terms which are used in science assessments can cause confusion for students as they are not particularly familiar, for instance, the word *obtain*. Keep track of which terms are tricky for your students, and incorporate them into general classroom talk to increase your students' familiarity with them.

Suggested strategies for teaching vocabulary for exams/assessments

- **Model highlighting.** Highlight and underline command words when modelling how to answer exam questions. Refer to the exam board guidance about what is expected for each command word, and make it clear how you meet the expectation.
- **Command words.** Use command words when asking questions in class, with one student *describing* then another *explaining*, and then a different student *comparing* and *contrasting* with a different scenario, and another *evaluating* or making a *suggestion*. Try to use the same command words as students will meet in their exams.
- **Identify the command word.** Provide students with a question which is missing the command word. Ask students to use their bank of command words to come up with as many variations on the question as possible and the different answers to each one.
- **Avoiding vague language.** Provide students with exam questions with vague scientific language, and task them with writing an examiner report on the key errors being made. Include key misconceptions, such as *strong* used to describe a *concentrated* solution.
- **Definitions.** In groups of three, students can play the definitions game for learning exam-specific scientific terms. One student has a card with a word and its corresponding definition and acts as 'definition master'. The 'definition master' gives another student a term, which they then define. The 'definition master' awards points for each correct definition. However, if that student hesitates or makes a mistake, their opponent can 'buzz in', and steal the points if they can complete the definition correctly. The students switch roles each time.
- **Games.** Play vocabulary games, including Scattergories, Articulate, Just a Minute, the association game, Pictionary or Taboo using key vocabulary from the whole course. Here are some suggestions using Teachit Science resources: Respiration connections game (20025), Bonding: keyword cards (28723), and Inheritance – taboo (28970).

Independent learning tasks

- **Exam questions.** Provide students with a list of the command words from your exam board. Based upon the tasks set in class, get students to write their own questions using these words.
- **Sorting out the misconceptions.** Get students to create their own mnemonics or rhymes to help to iron out common misconceptions as identified by your exam board.

Closing the word gap: science

Section 2: Vocabulary to improve your students' writing

Here are Emily Seeber's suggestions for effective classroom strategies to develop students' ability and confidence in using key vocabulary in their written work.

1. Read all about it

Students find it challenging to engage with scientific texts. Few texts contain a driving narrative, but almost all use a wide variety of technical and semi-technical terms, as well as a complex web of logical connectives. Reading a range of scientific texts models good scientific writing to students, as well as expanding their vocabulary. So how can we help students to engage with scientific texts to broaden and deepen their vocabulary for science?

DART activities (directed activities relating to text) can be used to ensure that students are engaging with the text. The type of DART activity depends on the form of the text:

Text	DART
Instruction e.g. the method for a practical task.	Sequencing instructions or adding in missing instructions.
Classification e.g. a description of different living organisms.	Highlighting or underlining the properties of each class then grouping these together into a table or a Venn diagram, or a muddled sentence task. You could use the Teachit Science resource based upon the topic of cells: Designed for the job (19383).
Structure text e.g. a description of a structure, such as the digestive system.	Highlighting or underlining information about each part of the structure, text completion, labelling the diagram, and annotating the diagram.
Mechanism text e.g. a description of how something works, such as distillation.	Highlighting or underlining information about each part of the process, text completion, labelling the diagram, and annotating the diagram.
Process text e.g. a description of a process, such as the carbon cycle.	Highlighting or underlining information about each part of the process, sequencing the order of the process, text completion, labelling and annotating a diagram, or designing or constructing a diagram or flow chart for the process.
Concept/principle e.g. an abstract account on the theory of natural selection.	Highlighting or underlining the main features of the theory, text completion, sequencing and labelling segments of text, or a muddled sentence task.
Hypothesis/theory e.g. a hypothesis about the origin of the universe.	Text completion, highlighting or underlining the features of the theory, and grouping these together in a table with the evidence for the theory.

(Adapted from Wellington & Osbourne, 2001)

Highlighting and underlining are excellent starting points for students reading a text, but students can find themselves highlighting the whole page. Using a system consistently can be helpful for students: scientific terms in green, command words in blue, facts in yellow, and opinions in purple.

Some of these DARTs require the text to be modified before students engage with it. Sequencing requires the teacher to mix up the correct order of the instructions. A muddled sentence DART mixes up definitions or key information for students to piece together to write whole sentences. Here's an example:

Use the framework below to write definitions for *DNA, chromosome, gene*, and *allele*.

A	B	C	D	C
DNA An allele A gene A chromosome	is a polymer is one is a group is a thread is a small section	of RNA of DNA in a double helix version in a single helix of a chromosome	of different of the same which contains found which codes for	in the cytoplasm. genetic information. a sequence of amino acids. gene(s). in the nucleus. a specific protein.

Answers:
DNA is a polymer in a double helix which contains genetic information.
An *allele* is one version of the same gene.
A *gene* is a small section of a chromosome which codes for a specific protein.
A *chromosome* is a thread of DNA found in the nucleus.

A text completion task usually resembles a gap-filling exercise. If the vocabulary is very new, you may wish to provide terms to be filled in at the bottom or on an accompanying diagram. You could differentiate further by including definitions for these new terms.

Alternatively, add a level of challenge by giving too many or too few terms, or none at all. You could even require students to adjust the grammatical forms of words to make sense of the text. This builds their fluency with using scientific vocabulary and is demonstrated below.

Read the following text and fill in the gaps using the terms provided. You may use each term once, more than once, or not at all. You will need to change the grammatical form of the word for it to make sense.

The nucleus of an atom contains ____________ and ____________. ____________ charged ____________ exist inside the atom, but outside the nucleus, and have negligible ______. The electrons can be ____________ from one material to another if one of the materials is a good ____________. The materials both become slightly____________. One ____________ electrons and becomes ____________, and the other loses ____________ and becomes positive. These ____________ are known as ____________ electricity.

electron	mass	negative	charge	static	induce
insulate	gain	proton	transfer	neutron	share

Answers:
protons, neutrons, Negatively, electrons, mass, transferred, insulator, charged, gains, negative, electrons, charges, static

Using associated diagrams with text labels allows students to dual code the information as both words and images, improving recall from long-term memory. Try to use up-to-date, high-resolution images.

Other DARTs do not need text to be changed but require the teacher to provide a diagram or table for students to fill in while they are reading the text.

Read the following text, and then complete the table below with statements about boiling and evaporation:

> Boiling and evaporation both involve a liquid turning into a gas. However, during boiling all of the particles have sufficient energy to overcome the forces of attraction between the particles, but in evaporation only some of the fast moving particles have enough energy to escape. Boiling takes place only at the boiling point of the liquid. In contrast, evaporation can happen over a range of temperatures, but the rate of evaporation increases with temperature.

Boiling	Evaporation

2. Semi-structured discussions for better writing

Group discussion can be an effective and efficient means of ensuring students are discussing scientific ideas and using terminology in a range of contexts. This provides important preparation for students completing independent written work (see strategy 4 below) in which a high level of literacy is required.

However, group discussion can easily stray off track without careful monitoring. To keep students focused, a few ground rules of discussion can be agreed by you and/or students at the beginning of the task. Over time, they can add new guidelines for monitoring discussions according to their experiences, generating their own norms and procedures. This is a powerful way of ensuring high-quality discussion.

Even with ground rules in place, the discussion needs to have some structure to help students to focus on the task at hand. Various different prompts can be used to centre the discussion.

Instance tables

Many 'instances' in science can be used as stimuli for discussion:

- an observable phenomenon, for example a man failing to push a train
- explaining an anomalous result from an experiment
- evaluating conclusions which could be drawn from a practical.

Discussing instances like these in small groups can ensure that the whole class is thinking and using the intended terminology, not just the student that is giving the answer in a whole-class scenario. A table can be given as a prompt (Wellington & Osbourne, 2001), as demonstrated later in the lesson idea and accompanying resource.

Concept cartoons

Concept cartoons provide a range of student perspectives on a situation for the group to evaluate and discuss. These feature a visual stimulus and a range of characters with different perspectives (Naylor & Keogh, 1999). The perspectives provided usually contain key misconceptions, correct statements, and irrelevant statements. In their groups students can determine:

- which statements are true or false
- which statements are plausible or implausible.

Students might be asked to:

- correct false statements
- improve statements so that they use more sophisticated scientific terminology
- write an explanation for the phenomena using ideas from the concept cartoon
- suggest methods of testing the implausible statements.

As students interrogate the statements with their groups, they will necessarily be engaging with the language used in the statements. In some cases, this may be discussing whether a word is being used in the correct context and replacing it with the correct term, or engaging with the syntax to evaluate the overall meaning, potentially changing the structure of the statement in order to correct it. Small groups can feed back to the class with their ideas and draw on their rich group discussions to express the conceptual content using more advanced terminology.

Students can also work in small groups to produce their own concept cartoons. Prompts are also helpful here. For example:

Produce a concept cartoon about evaporation and boiling. Make sure you include:

- one correct statement about evaporation or boiling
- one incorrect statement about evaporation or boiling
- two statements which can be corrected by changing one word
- one correct statement which links evaporation and boiling
- one incorrect statement which links evaporation and boiling.

3. Take note

Given the volume of information in the science curriculum, students' files and exercise books tend to be full of notes, but while copying from the board or receiving handouts is a safe method of ensuring students have all the notes they need, they become passive recipients.

Students need to learn how to extract the key information from talk and text, and how to structure this information into a readable format. Moreover, this is a skill which needs to be taught in science lessons.

Modelling

It is important for students to understand the thought processes required by teachers when making notes. Teachers should model this for students before they have developed their own note-making skills. Here are some ideas for how to model note-making:

- When you have gone through information on the board, ask students to pick the most important piece of information for their notes. Discuss with them which information they chose, which you would choose, and why. Then students can add the information discussed in their own words.

- Ask students to suggest key terms used during the lesson and then structure these into notes to summarise the lesson.
- Ask each pair of students to put a fact from the lesson on the board. Then model how to go through the statements and decide which ones are important enough to include in notes. Cross out the statements which do not make the cut, and ask students to work in pairs to summarise the remaining statements for their notes.
- Add annotations to your notes on the board or visualiser in response to classroom discussion in order to highlight misconceptions, exam technique, terminology, or examples. Encourage students to annotate their own notes with this kind of information when it is relevant to them (for example, if they are unsure of a definition).

Annotation

Good note-takers annotate their notes as they are listening to or reading information. Ensure that handouts don't include all the required information so that students can add in diagrams, annotate definitions, give examples, and make links to prior learning. Differentiate for your classes by varying the structure and the amount of information you give to students.

Writing frames

Provide writing frames with subheadings so that students' notes are organised and relevant.

This is particularly helpful when you want students to make notes from a text or a video. Students can then write information only into the pre-identified categories, discarding information which does not fit under any of the headings.

The next level skill is for students to define the categories themselves. Use short videos or texts in class, and on the first viewing or reading students suggest the headings. Then, with the agreed headings, students watch or read for a second time, this time taking notes. Students can evaluate the effectiveness of the categories afterwards.

4. Extended writing

Spending time on extended writing in science lessons is not common (the exception being the ubiquitous experimental write-up), but it is important to make time for writing if students are to develop key literacy skills, such as choosing the appropriate vocabulary and register for the audience, and being able to express their scientific reasoning. Making posters, writing scientific articles, letters and speeches and even writing formal essays, are all a valuable part of science teaching.

Examiner reports from June 2018 noted that students were hampered by poor scientific writing: answers were vague, rambling, or even incoherent, and either they lacked scientific terms or those terms were used imprecisely (AQA, 2018). By building in opportunities for extended writing in science, we can support students in developing the skills required to access summative assessments.

Experimental write-up

Writing frames can be used with students to help them to set out their plans or write-ups. Of course, not all practical work needs to have a formal write-up, and for some the received structure is not appropriate. In these cases, discuss with students why a standard write-up is not appropriate, and suggest or use alternative approaches.

A quirk of reporting scientific research is that it is written in the passive voice. This is fairly unfamiliar to students, but it is something that can be developed through their ordinary science practical work and is certainly something to consider when challenging students.

- Write instructions for a practical using the first person, the imperative, and the passive voice. Mix up the statements, and get students to sort them into three groups. Discuss why they might use different verb forms for different audiences.
- Provide students with instructions written in the first person, and ask them to rewrite the instructions using the passive voice.
- Encourage students to complete wider reading of scientific literature written in the passive voice, providing them with appropriate articles.

Extended articles/letters/speeches

The most challenging part of setting students extended writing tasks in science is coming up with valuable subjects for them to write about. The topics will depend on your department's scheme of work. Keep a list of ideas in your department workspace that people can add to as they have ideas. Here are some suggestions for extended writing in chemistry:

- an exposé about Antoine Lavoisier getting all the credit for the discovery of oxygen, rather than Priestley or his wife Marie-Anne
- a speech by a forensic chemist to a jury which details the evidence found at the scene of a crime and its implications for the case
- a report for the Food Standards Agency on the vitamin C content in different brands of orange juice
- an article on the 'wrong turns' taken in chemistry, such as the blind alley of phlogiston
- a speech to be given to the UN on the importance of carbon-neutral chemistry
- an essay on 'What was the most important discovery in the search for the structure of the atom?'

A range of strategies can be used to support students' extended writing:

- group discussion of the issues (using a concept cartoon, instance table, or concept map)
- writing frames with suggested word counts for each section
- redrafting after feedback, at least once
- highlighting areas where students could adjust the tone or register of their writing and words which could be replaced with more scientific terms.

Poster competitions

Posters are important forms of communication in scientific research, with poster prizes for the best entries. This can work equally well in classrooms, with students producing posters to demonstrate their research, experimental results, or a summary of a topic.

To ensure that students produce good-quality posters, it is useful to share success criteria with them before they begin.

You could share the following grid with students to show them the marking criteria:

	Good (1 mark)	Very good (3 marks)	Excellent (5 marks)
Terminology	Scientific terms are used, generally in the appropriate context.	Scientific terms are used correctly, and some are defined.	A range of scientific terms is used and all defined appropriately.
Expression	Good use of standard English, including full sentences, and bullet point lists where appropriate.	Correct use of standard English throughout, including a range of expression.	The tone is appropriate for the audience, including the passive voice where appropriate.

Structure	The poster has been organised into sections.	The poster has been organised into helpful sections which are clearly marked.	The structure helps the reader to grasp the key points quickly and easily.
Diagrams	A relevant diagram has been chosen.	Two or more relevant diagrams have been chosen and used appropriately.	Relevant diagrams have been designed to clarify the information.

Students can then peer or self-assess their posters on the quality of scientific communication. They might use sticky notes in four different colours to leave comments on posters for improvement. Students can then focus on improving their poster in the area in which it was least successful.

5. Focus on logical connectives

It is not just scientific terms which form part of the vocabulary gap in students: many logical terms used in science classrooms pose difficulties. Students can either miss key points in their scientific reasoning or develop misconceptions about the theory they are learning.

While *therefore* and *because* are used in science classrooms regularly, students struggle with *accordingly* and *conversely*. Use a range of logical connectives in your talk, and give synonyms and explanations for them on a regular basis, until you are confident of students' understanding.

Teacher: Copper is below hydrogen in the reactivity series, ***hence*** *it does not react with acids.* ***Because*** *copper is below hydrogen in the reactivity series, it is too unreactive to react with an acid.*

In this example, the teacher makes the same argument twice: a more advanced logical connective, *hence*, is clarified by following it with a simpler one, *because*.

Word completion tasks allow students to reconstruct the scientific reasoning covered in the lesson using logical connective terms. These should include familiar and less familiar words, challenging students to think through the scientific content as well as the meanings of the individual words.

> Diffusion is an important concept for understanding transport in cells. Particles in gases and liquids move randomly. The overall movement is ____________ from an area of high concentration to an area of low concentration. In the lungs, oxygen diffuses from the alveoli into the blood, ____________ carbon dioxide diffuses from the blood into the lungs. ____________, urea diffuses from an area of high concentration in the liver into the blood, where it is transported to the kidneys to be filtered.

Choose the correct combination from the options below.

A	consequently	and	conversely
B	essentially	but	similarly
C	consequently	however	in contrast
D	thus	and	analogously

Answer: D

Potassium is more reactive than sodium ___________ a potassium atom is larger, ___________ the force of attraction between the nucleus and the outer shell is weaker ___________ the greater nuclear charge in a potassium atom.

Choose the correct combination from the options below.

A	hence	so	despite
B	since	thus	in spite of
C	nevertheless	consequently	in spite of
D	because	consequently	in accordance with

Answer: B

When a skydiver jumps out of a plane, the only force acting on them is their weight; ___________ , they start to accelerate downwards. Air resistance increases ___________ the speed, and ___________ the drag increases.

Choose the correct combination from the options below.

A	therefore	in line with	nevertheless
B	hence	similarly to	inevitably
C	because	conversely	naturally
D	therefore	in accordance with	consequently

Answer: D

Discuss together why one logical connective works better than another in different instances, reflecting on the tone created by the term as well as on the literal meaning. Help students to produce more interesting scientific writing by giving feedback on their use of connectives.

Lesson idea: Concept maps

Topic: Any

Materials required: A concept map framework photocopied onto A3 paper, sticky notes or A3 blank paper, and a list of terms.

Activity

Mapping and linking key terms in a topic can be done using a concept map. Students articulate their understanding by annotating the links between terms. For example, a link can be made between the terms *acid* and *alkali*, and the link could be annotated with *these neutralise each other.*

Concept maps work effectively in groups because students can be more sophisticated in their choices. Collaboratively, they will also discuss and refine their linking statements. This 'chunking' secures information in students' long-term memories. Differentiate by varying the amount of information you provide, as per the suggestions below.

After the activity, students can evaluate other groups' efforts. One method is to set up the concept maps in an exhibition and allow students to move around the room adding sticky notes to maps with questions for the creators to respond to. This might be suggesting a new link they have missed or questioning how the link has been articulated. Students then return to their own maps and respond to queries about their observations of other maps, as well as the comments left on their map.

Teaching tips

- If concept mapping is new to students, you may wish to provide them with a map, including the links and terms, and simply ask them to annotate the labels, or provide them with a concept map which includes errors to correct.
- However, if students are comfortable with the process, you may wish to simply provide the list of terms and ask students to cut them out and arrange them on A3 paper themselves, making as many links as they can. An example is provided on the next page.
- You may even wish groups to identify the vocabulary themselves or allow them to add more terms to their concept map.
- There is also a version of a concept map on Teachit Science, Keyword links template (30485).

Independent learning tasks

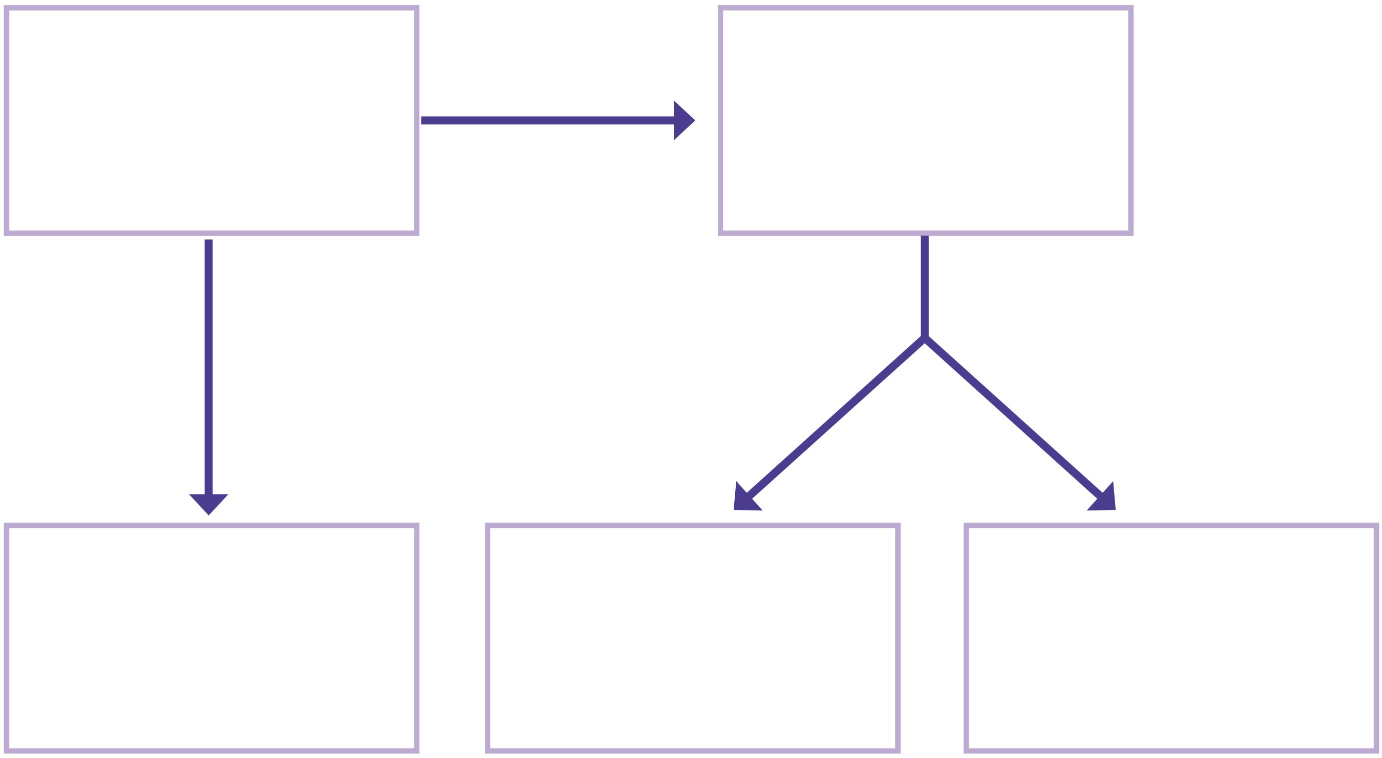
- Encourage students to progress in their independent ability to construct concept maps alongside the development of their vocabulary by reducing the level of support you provide.

Classroom resource: Concept map

Here is a set of terms. Your task is to arrange them onto A3 paper to demonstrate the links between the terms. Explain the links between the terms by writing along the arrows.

Your arrows could have more than one pointed end and could split in more than one direction, as shown on the example which follows.

speed	velocity	resultant force	mass
friction	air resistance	weight	acceleration
gravity	distance	terminal velocity	time



Lesson idea: Discussion statements

Topic: Any

Materials required: A series of discussion statements on a relevant topic.

Activity

As described earlier, the use of instance tables is an effective discussion mechanism which promotes students' own use of key terminology. In small groups, students can interrogate their understanding of a topic, and in providing a set of targeted common ideas in the form of statements you can steer students towards the use of appropriate academic vocabulary.

This activity works best in three stages. Firstly, students have a chance to read through the statements independently. Secondly, students discuss the statements in small groups and fill in the table with their resolutions. The independent reading beforehand ensures faster readers do not dominate the conversation. Finally, groups feed back to the class, and you provide the perspective of a scientist on the statements. You can differentiate further by asking groups to add their own statements, with supporting evidence.

An example of a complete activity for the topic of plant growth is demonstrated in the accompanying resource.

Teaching tips

- You could base this activity upon a text and treat it as a comprehension activity (as discussed in strategy 1).
- To expose students to a greater variety of evidence sources, you could give them a number of supporting source texts on the relevant topic.

Independent learning tasks

- To develop students' use of subject-specific terminology, challenge them to compile their own lists of statements based upon a topic. Ensure they include correct statements, incorrect statements, and some which contain elements of both.
- Provide a list of accompanying key vocabulary which students should aim to use in the discussion phase. As an extension of the evaluation phase, get students to write up their conclusions, making use of these terms.
- Challenge students who are already confident with a variety of vocabulary on the given topic to act as observers in the discussion phase of this activity. They should note down any key terminology used by the group.

Classroom resource: Discussion statements

Below is a selection of common ideas about plant growth. Some are correct, but some are not. Firstly, read through the statements on your own.

Secondly, discuss with your group whether each statement is correct, incorrect, or you do not know. For those you are sure about, make a note of the evidence upon which you base your beliefs.

Finally, see if you can add some extra correct statements of your own, with evidence.

Statement	Correct	Incorrect	Don't know	Evidence
Plants can grow in the dark.				
Plants take in oxygen and give out carbon dioxide.				
Plants give out oxygen and take in carbon dioxide.				
Plants get their food from the soil.				
Most of the matter in a plant comes from the air.				
Plants do not respire like humans.				

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