Developing literacy in secondary science

A National Literacy Trust membership resource

Research and background on the role of literacy in science

A **Review of SES and Science Learning in Formal Educational Settings: A Report Prepared for the** EEF and the Royal Society, 2017 found that there is an attainment gap in science between disadvantaged pupils and their classmates at every stage. The gap first becomes apparent at Key Stage 1 (ages 5-7) and increases throughout primary and secondary school.

The researchers found that the strongest factor affecting pupils' science scores is their literacy level. According to the report, poor literacy skills can affect how well a pupil is able to understand scientific vocabulary and prepare scientific reports. This suggests that strategies that develop disadvantaged pupils' reading comprehension and academic writing skills could have a positive impact on their achievement in science.

The **Education Endowment Foundation's, 'Improving Secondary Science' (2018)** includes several strands pertinent to the development of literacy in science:

2c: Promote metacognitive talk and dialogue in the classroom
6a: Carefully select the vocabulary to teach and focus on the 'most tricky' words
6b: Show the links between words and their composite parts
6c: Use activities to engage pupils with reading scientific text and help them to comprehend it
6d: Support pupils to develop their scientific writing skills

This teacher resource will provide some subject disciplinary theory as well as practical strategies to support literacy leaders and science teachers implement actions recommended by these two research and guidance sources.

What do we mean by the language of science?

The science disciplines have created a language that describes their knowledge organisation.

> *"Learning Science means learning to talk science. It also means learning to use the specialized conceptual language used in reading and writing, in reasoning and problem solving, and in guiding practical action in the laboratory and in daily life. It means learning to communicate in the language of science and to act as a member of the community of people who do so."*
>
> *Lemke, 1990*

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Reading and writing about the sciences can be challenging because the language structures are complex to express the complexity of scientific thought.

> *"The relation of thought to word is not a thing but a process, a continual movement back and forth from thought to word and from word to thought. Thought is not merely expressed in words; it comes into existence through them."*
>
> *Lev. Vygotsky 1986*

All students need to understand how scientific 'texts' work, so they can read and write about science fluently and precisely. This involves much more than learning subject-specific vocabulary.

> *"The difficulty lies more with the grammar than the vocabulary… the problems with the technical terminology usually arise not from the terms themselves, but from the complex relationships they have with each other."*
>
> *M.A.K. Halliday and J.R. Martin 1993*

Here is a typical paragraph of science explanation writing:

> Table salt *is produced* from sea water or *is dug out* of the ground or *extracted* using **'solution mining'**. In this process, water *is pumped* into layers of salt underground. The resulting salt **solution** *is* then *heated*, which **evaporates** the **solvent** and makes the *(salt)* solution more and more salty. Eventually it reaches a point where there is as much salt in the water as can possibly **dissolve**. This is a **saturated solution** and it contains the maximum amount of **solute** that can **dissolve** in that amount of **solvent** at that temperature. If more water **evaporates** and/or the **solution** cools, then some solute leaves the solution so salt **crystals** form.
> Pearson Edexcel GCSE Chemistry 9-1 Student book sample

Most teachers would draw attention to the subject specific words in **bold**. But other aspects such as passive verbs *(italic)* and the reference words (underlined) also make the text more difficult to read.

EEF Strand 2c: Promote metacognitive talk and dialogue in the classroom

Different types of talk occur in science classrooms. Science practical sessions are an ideal place to encourage dialogue and exploratory talk. Yet, without conscious planning what the teacher is likely to hear is 'talking while doing' rather than formal scientific discourse. Students working together on a shared task tend not to use specialist vocabulary as they can see what each other is doing.

The sample below was collected in a middle school science lesson:

> *This … no, it doesn't go … it doesn't move… try that … yes, it does a bit … that won't … won't work, it's not metal … these are the best … going really fast.*
>
> Gibbons 2002

You'll notice that there are very few nouns in the passage; that most of the discussion is about what is happening and words that 'point' to things (these, it, that).

Teachers can improve the quality of classroom dialogue by asking pupils to report formally what they have found out. This requires pupils to produce extended utterances and use technical terms. They should also avoid reliance on the typical Initiation, Response, Feedback (IRF) exchange (see box on right) which is commonly observed by classroom researchers. This type of dialogue doesn't stretch students' spoken language, nor is it likely to consolidate subject specific vocabulary understanding.

> ***Teacher:*** *Who can tell me what this is?*
>
> **Student 1:** *A tripos*
>
> ***Teacher:*** *Not quite… can anyone else help?*
>
> ***Student 2:*** *A tripod*
>
> ***Teacher:*** *Well done!*

Through hypothesising, speculating, predicting, deducing and problem solving, students and teachers can engage in 'exploratory talk' (Mercer 2008). The science classroom is a good space for promoting exploratory talk using strategies which include:

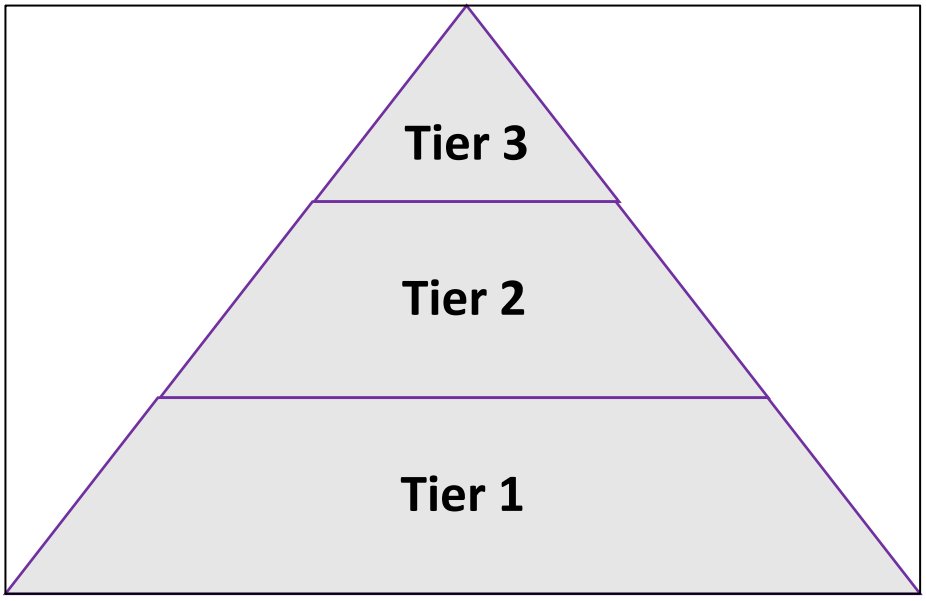
- Presenting real problems for groups to solve
- Organising pupil groups and roles within groups carefully
- Giving pupils time to listen and reflect on others' talk
- Challenging and extending talk through open ended questions
- Providing good models of talk – through dialogues with additional adults such as a teaching assistant or technician
- Circulating around working groups asking open questions such as, *'why do you think x is happening? … how did you work that out? … is there a better way of doing this? … Can you describe the pattern …?*

EEF Strand 6a: Carefully select the vocabulary to teach and focus on the 'most tricky' words

Teaching and learning subject specific vocabulary in science is a huge challenge, not least because the new vocabulary is largely new concept and content knowledge too. Many of the 'trickiest'

words in science are hard to understand because they are already well known in other contexts. Words like power, function, conductor and wave may need additional unpicking because they mean something else in another subject. It is also helpful to think of words in three tiers:

- **Tier 1** describes the high frequency, everyday words used at home and in school. Pupils will mostly be very familiar with these. Although it worth remembering that EAL learners will not necessarily know the words for common household objects as they would use their home language to talk about these things (*e.g. kettle, tap, spoon*)
- **Tier 2** describes medium frequency words that are more likely to appear in books, both fiction and non-fiction in any context. These need to be clarified and taught by teachers of all subjects and would include question command words and many analytical verbs (e.g. *evaluates*, *implies, demonstrates, suggests, qualifies*)
- **Tier 3** refers to low frequency vocabulary that appears only in a subject-specific context. In science, this includes both **concrete nouns** used for naming and identifying physical features or observable phenomena which are quite straight forward to learn with the support of diagrams and pictures *(e.g. heart, Mercury, pipette).* But defining and understanding abstract nouns used for processes (e.g. energy transfer, distillation, osmosis) may take an hour, a week, or a lifetime.



Low frequency subject specialist or technical vocabulary: *corrosion, metamorphosis, decibel.*

Medium frequency academic vocabulary: *function, estimate, quantitative*

High Frequency everyday words: *sun, kettle, flower.*

Adapted from Beck, Mc Keown, Kucan (2013)

EEF Strand 6b: Show the links between words and their composite parts

The Oxford Dictionary includes approximately 10,500 words of Greek origin, which constitutes 21.6% of the dictionary. Approximately 80% of Scientific and technical English derives from Latin or Greek (often via French) when teacher can highlight the etymology and morphology of these words, students are able to build their vocabulary and interpret unknown words more easily.

Some of the essential root or base words are introduced during KS2 (e.g. aqua, terra, geo, bio) as are the most common prefixes and suffixes. Older and more advanced students will need a more comprehensive list such as the one provided here: Biology Junction Prefixes and Suffixes
Another technique for word building is to ask students to construct word webs or word-building matrices as follows:

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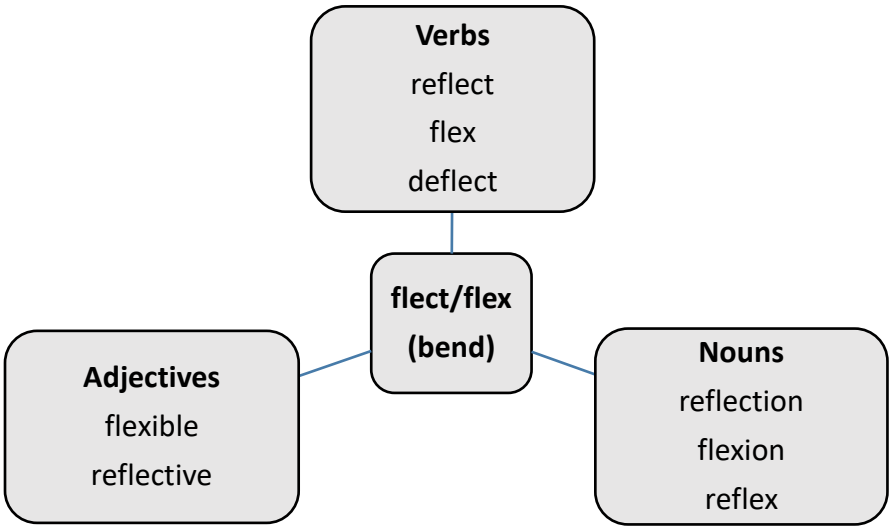
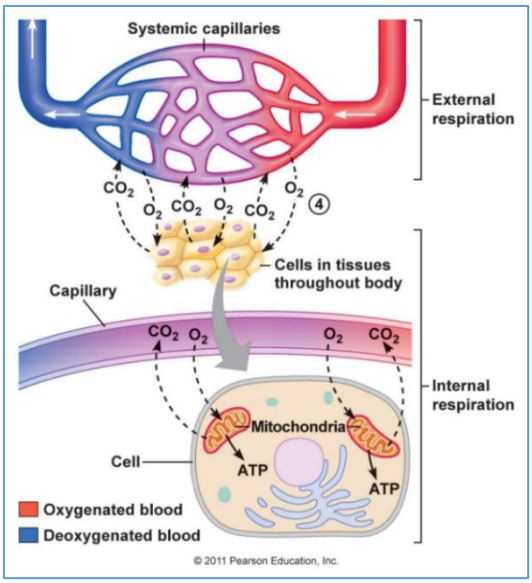


e	**Vapor** Steam, heat	ate	es ing ion
		ise	ed es ing

You might also provide a glossary template in the form of a '**Have you heard the word?'** grid available on our Developing language and literacy in science page, which enables students to build up their own personal subject vocabulary lists and revisit words as they go through a unit of work while thinking about how and when they use them.

EEF strand 6c: Use activities to engage pupils with reading scientific text and help them to comprehend it

Science texts books present different challenges to reading in English or Humanities. Science texts are highly *multimodal;* meaning and concepts in science are conveyed as much through number, data and diagrams as they are through text. EAL learners and those from other cultures and education systems may not be familiar with the wide range of visual forms we use to convey meaning. Shape, orientation, colour, bold, underlining, font size, captions, layout are all significant in the example here:



One way to develop the reading of scientific, multimodal texts is to use **Directed Activities Related to Texts** (DARTS) These strategies and techniques are particularly helpful in learning how to read challenging science texts where students need to be able to deconstruct and reconstruct organs, organisms, systems and machines and explain relationships between parts and the whole. (Davies and Greene, 1984.)

Reconstruction (Synthesis) Activities	**Deconstruction (Analysis) Activities**
Text completion Pupils predict deleted words (cloze), sentences or phrases.	**Underlining or highlighting** Pupils search for specific target words or phrases that relate to an aspect of content.
Diagram or table completion Pupils predict deleted labels on diagrams/ tables using text and /or visual sources.	**Labelling and segmenting** Pupils segment paragraphs or text into information units then label segments of text which deal with different aspects.
Completion activities with disordered text a) Predicting logical order for sequence b) Classifying segments according to categories given by the teacher.	**Diagram construction** Pupils construct diagrams from the information in the text. E.g. flow diagrams, concept maps, labelled drawings, models.
Prediction Pupils predict the next part(s) of text with segments presented in sequence.	**Tabular representation** Pupils extract information from a written text, then represent it in tabular form.

You can download some sample DARTS activities from our Developing language and literacy in science resource page.

EEF strand 6d: Support pupils to develop their scientific writing skills

> *"Writing about science is more than communication alone; it supports pupils in their learning because when they write about science they reflect on their understanding, formulate their own ideas, and combine ideas in new ways."*
>
> EEF Improving Secondary Science 2018

Science teachers can support pupils' writing by following a sequence for 'slow writing.' This allows pupils to become familiar with both subject content and the intended written outcomes before embarking. Good writing always starts with good talk (see spoken language section above). Then, following a clear *I do, we do, you do* sequence can be very supportive, especially for weaker writers.

I DO

1. **Establish clear aims.** Share the purpose, form and intended audience of the piece of writing e.g. a brochure for zoo, exam question, analysis of graphical data.
2. **Provide a good model.** Either write or find a model text to share with pupils.
3. **Explore text features.** Read together and identify typical language features e.g. passive verbs, logical conjunctions, abstract nouns. Also use a plan if it is extended writing.
4. **Demonstrate how to write** through shared writing in front of the class and thinking aloud to illustrate the choice of words and sentence structures.

WE DO

5. **Compose together.** With students suggesting and adapting words and phrases, the teacher improves the paragraph. Give pupils practice using unfamiliar sentence patterns.
6. **Shared or collaborative writing.** Students begin their own writing with a pre-written plan, sentence prompts or peer support as required.

YOU DO

7. **Independent writing** to complete the writing task.
8. **Review and improve.** The last stage may be teacher led, or students can mark or improve each other's work using a success criteria checklist.

References

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