# Inclusive teaching in science

# Strategies

**Contents:**



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# Introduction

*This interactive workshop will help you link GCSE Required Practicals to your scheme of work and pupils' experiences. Suggested activities support the required practical, focusing on introductory and follow-up activities that relate to pupils' experiences and science careers. These activities will help pupils develop skills such as problem solving, extended writing, application and analysis.*

**What you can do:**

**Include tasks to encourage participation**

- Get individuals involved in whole class activities e.g.
  - responses written on mini-whiteboards/back of book
  - use plickers for whole class questioning [a downloadable app; pupils respond anonymously to multiple choice questions ]
  - think-pair-share [pupils consider a question individually, share answers with a partner, then discuss in a small group]
- Include paired or group work (you may want to allocate roles) e.g.
  - structured discussion within a group e.g. respond to a scenario
  - planning the experiment; complete a template based around the practical/context
  - joint presentation or research task
- Encourage reflection
  - Use structured peer/self-review using clear marking criteria

**Ensure resources and tasks are accessible and relevant**. Then review again.

- Let pupils choose if they need support materials.
- Language issues
  - Provide a glossary of scientific terminology
  - Low literacy skills: use bullet points and headers, writing frames, images
  - Provide a dictionary if English is a second language:
- Summarise prior knowledge needed
- Chunk open-ended tasks e.g. structure calculations, provide a writing frame.

**Include tasks to develop pupils' different skills**

Remind pupils that engineers and scientists use a wide range of skills.

- Include creative, or open-ended tasks
  - Literacy: extended writing/reporting
  - Numeracy: calculations using results to reach a conclusion or solve a problem
  - Problem solving: e.g. finding solutions, testing predictions
  - Research skills e.g. use online/printed resources or practical work; web quests etc
  - Creativity: e.g. model building, posters, role-play
  - Presentations

## Examples of inclusive contexts:

Inclusive contexts are of interest or relevance to all groups, including gender, socio-economic group, race etc. Inclusive topics may:

- Impact on groups equally
    - Weather, currency, communication e.g. mobile phones
- Be of general interest or relevance
    - Universe, preventing disease, transport, entertainment e.g. music
- Represent members of all groups, or show them actively involved
    - Olympic sports

## Hints for planning and selecting gender inclusive resources

| | **Gendered** | **Neutral** | **Inclusive** |
|---|---|---|---|
| **Language used:** | His/hers,<br>(s)he, him/her, | Theirs, them, they | You, your, or use of names |
| **Role models** | e.g. males active & females passive | Roles e.g. pupil, scientist | Males & females have active roles |
| **Relevance, context** | Stereotyped male or female | Not related to people or situations | Suitable for both genders |

| **GCSE required practical Topic** | **Inclusive context (calculations; extended writing)** |
|---|---|
| Density | Compare density to identify full-sweetness, and diet drinks<br>Confirm density to test if a coin is genuine |
| Extension | Weighing astronauts (using a spring in space; F=ma = kx)<br>Designing clothes (for athletes)<br>Extrapolate results to choose a length of bungee cord |
| Speed, acceleration | Vehicle crash tests; accident investigations<br>Olympic sports |
| Observing waves | Communication underwater<br>Wave speeds in fresh water and salt water<br>Using EM waves to help survivors of an earthquake |
| Energy changes and transfers | The best liquid for a cooling system (SHC)<br>Microwave cooking instructions for a ready meal<br>Depth of a crater on the moon (mechanical work) |
| Circuits | Designing an electrically-warmed glove for astronauts<br>Design and test a lie-detector (resistance of dry/wet skin)<br>Circuits at a concert venue or in the home |
| V-I graphs | Designing a temperature sensor for a hospital incubator |
| Refraction | Identifying transparent materials/liquids using refractive index<br>Quality control: gemstones, soft drinks |
| More than one experiment | How vending machines identify coins |

## Supporting students with science language

| Focus | Strategy |
|---|---|
| Introducing new terminology | Teach new concepts using everyday language first<br>Introduce new words in context initially<br>Plan how to introduce new words before the lesson<br>Provide a glossary or list of topic key words |
| Sources of confusion | Avoid alternative words e.g. apparatus, equipment<br>Highlight alternative meanings in science e.g. displacement<br>Highlight alternative everyday meanings or usage e.g. moment, weight<br>Write down similar sounding words e.g. weight and wait<br>Highlight letters with more than one use e.g. m = milli, metre, mass<br>Highlight the need to capitalize some letters e.g. V for volt, v for velocity |
| Vocabulary sheets, equation sheets, glossary: | Label symbols e.g. on circuit diagrams<br>Label equipment e.g. in diagrams<br>List quantities and their units<br>Link pictures, symbols and words e.g. ohm, Ω<br>Pupils may mix up quantities and units. Write equations in full initially e.g. charge Q (C)= current (A) x time (s) |
| General points | Non-english speakers: provide a dictionary or translation; use pictures<br>Use sans-serif fonts such as arial, verdana to help pupils with dyslexia<br>Colour blindness: maximize contrast; avoid colour coding if possible<br>Use a minimum font of 28 on PowerPoint |
| Instructions | Use the active voice<br>Limit vocabulary (e.g. don't use equipment and apparatus)<br>Pupils' reading age for science text is lower than their chronological age<br>Give instructions in different ways e.g. verbal, visual, written |

## Written group work

Successful group work improves participation - pupils are more independent so expectations need to be clear from the start. Group tasks include practical work, written tasks, projects, discussions etc.
Written group tasks include reading for meaning (pupils summarise and share different written extracts); planning (pupils work together to plan a group experiment or project); presenting research or a project.

**Hints to encourage productive written group tasks:**
I use a group template (or mindmap/table) to pull together prior learning, or for planning. I include success criteria on the template. Clear expectations are vital e.g. time limits; presentation style; feedback (e.g. self or peer assessment against criteria)
I make named pupils responsible for a specific section. Although individuals have responsibilities, the group should be responsible for full completion.

- Allocate roles at the start and hand out pupils the resources needed for each role (e.g. printouts, textbook pages, images). Without this "guidance", pupils may have a lovely chat, or complete the same section, or not write anything into the template
- Be clear what is needed in each section of the template (e.g. diagram/bullet points/description), and presentation style
- Circulate to ensure groups don't meander off the task, even if their conversation is relevant.
- If you want every pupil to have a copy of the template, give everyone a blank copy; each group member completes a different section then shares information with a partner and then with another pair.

## Spoken group work

The skills which speaking tasks improve include:

- spoken & listening - speak in full sentences using scientific language; listen to others; speak in turn; encourage others to speak
- collaboration/participation - insist that everyone contributes; involve quieter members by asking questions; work together to agree a group response.
- decision-making - decides on the most important/useful responses. Different opinions are fine but groups shouldn't let disagreements become personal

Provide prompts if necessary e.g. sentence stems, lists of key words/concepts and role cards

**Hints to encourage productive group discussions:**

Spoken group tasks include:

- responding to (controversial) open-ended questions, statements, demonstration, text or images e.g. do you agree with…/why do you think…/suggest the main reasons why...
- role-play (What would you ask Isaac Newton…? You are a newspaper reporter etc);
- planning e.g. for a practical, presentation or research task
- group presentations

Groups with a written copy of the question are more likely to work together - pupils are more likely to shout out if the task is on PowerPoint

- If you use written tasks, groups could look at different questions (e.g. the same problem/role play from different perspectives).
- Stand at the back of the room and circulate so pupils can easily check responses
- Monitor conversations – insist on discussions and full participation

**Hints for a productive think – pair – share:**

You can use think-pair-share as a starter, to apply learning, or for planning.

- Insist on *thinking time* (e.g. 30 second-1 min for each step is usually long enough)
- Give time for a few groups to share their responses with the class.

| **Question and sentence stems include:** | **Examples** |
|---|---|
| Discuss what you know about x … | Discuss what you know about recording results scientifically |
| What do you think about x? | Do you think petrol cars should be banned to protect the environment? |
| Can you give an example of/more detail…? | Can you give an example of how to make our results more precise? |
| What do you mean when you said…? | What do you mean when you said our results can't prove the coins are fake? |
| How do we know x is true? | How do we know the statement "light waves travel slower in glass" is true? |
| How do these results show that…? | How do our results show that drink X contains sugar and drink Y doesn't? |
| How could you prove ….? | How could you prove the accused person was at the scene? |
| I agree/disagree with statement x because… | I agree that space travel should be funded because… |
| I think our results/this image shows y because… | I think our results show the coins are fake because… |

## Literacy skills

Poor literacy skills have a disproportionate impact on disadvantaged students in science. The teacher's expectations can have a big influence on the effort pupils make with literacy in science. Other related skills include handwriting, and oracy (speaking)

In 2015, an international survey of 15-year olds showed a gender gap in skills in UK students. The reading gap was 20 points out of 600, maths gap was 11 points and science gap was 1 point. https://data.oecd.org/pisa/science-performance-pisa.htm#indicator-chart

## Extended writing tasks in your department

Pupils are more likely to benefit from:

- routine extended writing in each science subject
- a structured mark sheet, shared in advance
- a writing frame/sample answer if they need one
- an open-ended task, linked to a real-life scenario and science concept

## Things to include in an extended writing mark scheme:

- Evidence of an introduction and summary
- Use of paragraphs and correct SPAG
- Use of scientific terminology and examples
- Explanation of scientific concepts,
- Descriptions and/or explanations that link the science to the real-life scenario

## Sample writing frames

| **Extended writing should include:** | **Example starter sentences for pupils who need them (e.g. for a bungee jump)** |
|---|---|
| Introduction which identifies questions from the real-life scenario | In this essay I will write about… |
| Relevant science concepts identified and explained | Elastic objects stretch because…<br>Energy changes during a bungee jump are … |
| How the science relates to the question | Bungee jumpers could be harmed if …<br>Checks needed for a safe bungee jump are…. |
| More detailed science e.g. calculations that link results to the initial problem | We can work out the extension by…<br>Other equations we can use are…. |
| Explanation of how results will be used | The most suitable rope will… |
| Conclusion | In conclusion… |

## Extended writing tasks: examples that incorporate Required Practical results

### Investigating accidents [refractive index]

A forensic officer needs to check if fragments of glass in a suspect's trainer match glass from the crime scene. How can she check this?

You should:

- Describe tests you could use.
- Explain how you will use your results to check if the glass fragments match
- Extension: Describe other ways to confirm you have matched fragments correctly

You will be marked on:

- Science terminology, descriptions and explanations
- Choice of suitable experiments linked to the situation
- Structure (introduction and summary)
- Use of paragraphs, correct spelling and grammar
- Use of descriptive language

### Disaster relief [SHC]

Survivors of an earthquake need access to hot water and food, but fuel supplies are limited and there is no electricity. Their cooking equipment must use fuel as efficiently as possible.

You should:

- Describe the features of suitable equipment, including its design and material
- Explain how the results from your experiment helped you choose the material.
- Extension: Describe additional ways to help the survivors keep warm

### Bungee jumping [Hooke's law]

You are a safety officer working for a bungee jumping company. You train operators to use the correct type and length of ropes so jumps are safe in different locations and for different age groups.

You should:

- Write a safety report so operators know how to set up bungee jumps safely.
- Explain how to choose the correct length and type of rope, depending on the location and bungee-jumper.
- Use examples, including calculations

### Living on Mars [various]

You work for a company preparing for a mission to Mars. NASA has requested a design for their living unit, which has an inflatable, sealed living section supported in a frame.

You should:

- Describe the properties of suitable materials for the living unit, giving reasons
- Use the results from your experiment to suggest a suitable material for the frame
- Extension: astronauts will build the inner sections of the unit. Suggest suitable materials for these sections, giving reasons.

## ICEBREAKERS

Icebreakers are short contexts that are related to the topic. They are a way to include real-world examples, careers and refer to a diverse range of scientists. Their use can be versatile:

- starter or review e.g. list ideas; respond at back of book; think-pair-share; review prior knowledge; ask questions; discuss video
- as the basis for a longer task e.g. group discussion, plan an experiment, research, extended writing, presentation, poster

**Icebreaker**: As a Sound Engineer, you maintain and set up equipment for major concerts. What checks should you make before the performance?
https://www.thoughtco.com/how-to-set-up-a-stage-for-a-concert-2455751

**Icebreaker:** You are a zookeeper and think one of the giraffes is pregnant. How could you find out?
https://www.ksl.com/?sid=39216288&nid=148

**Icebreaker:** You are a Forensics Officer. How can you tell if a glass fragment comes from a crime scene?
http://www.spa.police.uk/forensic-services/chemistry/150713/

**Icebreaker:** You are a medical officer for NASA. How do you weigh an astronaut on the space station?
http://www.airspacemag.com/daily-planet/how-do-astronauts-weigh-themselves-space-180953884/

**Icebreaker:** You are a Quality Control Officer for the Royal Mint. How can you check the right metal was used to make new pound coins?
http://www.bbc.co.uk/news/business-39790777 and https://www.thenewpoundcoin.com/

**Icebreaker:** You are setting up a bungee jump from a bridge. What checks are needed so the bungee jumpers safely enjoy their jump?
http://www.bbc.co.uk/newsbeat/article/33626948/uk-bungee-club-explains-how-to-check-your-jump-is-safe

**Icebreaker:** You are investigating a lorry crash for the police. What tests could show if the brakes failed or if the road surface was at fault?
https://www.brlsi.org/events-proceedings/proceedings/18092

**Icebreaker:** You're a Food Technologist, planning meals for astronauts on the Space Station. How can you design meals that heat up fast?
https://www.nasa.gov/audience/forstudents/postsecondary/features/F_Food_for_Space_Flight.html

**Icebreaker:** You work as a food scientist, testing food for safety and quality. How can you check if milk has the right fat content and is safe?
http://www.fbp.ichemejournals.com/cms/attachment/2020792172/2040855918/gr4_lrg.jpg
http://www.milktest.jp/eng/milkchecker.html to check if cows have mastitis