

Conceptual Frameworks

Framework	Summary	How to Use in Practice	Link
EEF Guidance Report: Science KS3–KS4	Evidence-based approaches that improve science learning, including securing key knowledge, addressing misconceptions, sequencing, and designing purposeful practical work.	• Diagnostic lens when analysing PTE1 lessons: <i>“Which EEF recommendations are we not meeting here and what is the learning consequence?”</i> • Design filter when planning for PTE2: <i>“Does this plan reflect high-impact practice?”</i>	https://educationendowmentfoundation.org.uk/education-evidence/guidance-reports/science-ks3-ks4
Johnstone’s Triangle	Explains why science concepts are challenging due to movement between macroscopic, sub-microscopic, and symbolic representations.	• Analyse failed explanations: <i>“At which level did pupils get lost?”</i> • Redesign practical work: <i>“Does this task over-emphasise one level?”</i>	https://edu.rsc.org/feature/improve-students-understanding-with-johnstones-triangle/4019740.article
EEF RADAAR Planning Logic	Science-specific planning model: purpose → outcomes → tasks → assessment → responsive action.	• Planning backbone instead of activity lists: <i>“What is the learning purpose and how will we know it is achieved?”</i> • Reflection tool: <i>“Where did the breakdown occur?”</i>	https://d2tic4wvo1iusb.cloudfront.net/production/eef-guidance-reports/science-ks3-ks4/RADAAR_Planning_Logic_diagram.pdf
EEF BEST Task Exemplars	Concrete models of effective science task design showing learning logic in action.	• Use as planning exemplars • Benchmark own tasks: <i>“What is missing from my design?”</i>	https://d2tic4wvo1iusb.cloudfront.net/production/eef-guidance-reports/science-ks3-ks4/EEF_BEST_infographic_Digestion_v2.pdf

Great Teaching Toolkit (GTT)	Evidence review identifying key dimensions of effective teaching .	• Meta-framework for effective teaching • Name the dimension being addressed (e.g. <i>Activating Hard Thinking</i>).	https://evidencebased.education/the-great-teaching-toolkit-evidence-review/
STEM – Best Evidence Science Teaching	Curated evidence-informed teaching strategies (questioning, misconceptions, practical work).	• Source of exemplar strategies • Challenge weak practice with plausible alternatives	https://www.stem.org.uk/secondary/resources/collections/science/best-evidence-science-teaching
Rosenshine’s Principles of Instruction	Evidence-based instructional design (modelling, guided practice, checking understanding).	• Analyse explanation and modelling quality • Combine with Johnstone: “<i>How should I model at the sub-microscopic level?</i>”	https://www.aft.org/sites/default/files/Rosenshine.pdf
Estyn – Effective Assessment Guidance	How assessment improves teaching and learning in Welsh contexts.	• Evaluate AFL tasks • Test whether assessment leads to <i>next steps</i> not just marking	https://www.estyn.gov.wales/system/files/2024-02/Effective%20approaches%20to%20assessment%20that%20improve%20teaching%20and%20learning.pdf
Science Capital Teaching Approach (UCL IOE)	Increasing pupils’ science identity, relevance, and belonging.	• Evaluate lesson contexts and examples • Check whether relevance supports <i>sense-making</i> not just engagement	https://www.ucl.ac.uk/ioe/departments-and-centres/centres/centre-research-science-and-mathematics-education/science-capital

1

Preconceptions: Build on the ideas that pupils bring to lessons



- 1a: Understand the preconceptions that pupils bring to science lessons
- 1b: Develop pupils' thinking through cognitive conflict and discussion
- 1c: Allow enough time to challenge misconceptions and change thinking

2

Self-regulation: Help pupils direct their own learning



- 2a: Explicitly teach pupils how to plan, monitor, and evaluate their learning
- 2b: Model your own thinking to help pupils develop their metacognitive and cognitive knowledge
- 2c: Promote metacognitive talk and dialogue in the classroom

3

Modelling: Use models to support understanding



- 3a: Use models to help pupils develop a deeper understanding of scientific concepts
- 3b: Select the models you use with care
- 3c: Explicitly teach pupils about models and encourage pupils to critique them

4

Memory: Support pupils to retain and retrieve knowledge



- 4a: Pay attention to cognitive load—structure tasks to limit the amount of new information pupils need to process
- 4b: Revisit knowledge after a gap to help pupils retain it in their long-term memory
- 4c: Provide opportunities for pupils to retrieve the knowledge that they have previously learnt
- 4d: Encourage pupils to elaborate on what they have learnt

5

Practical Work: Use practical work purposefully and as part of a learning sequence



- 5a: Know the purpose of each practical activity
- 5b: Sequence practical activities with other learning
- 5c: Use practical work to develop scientific reasoning
- 5d: Use a variety of approaches to practical science

6

Language: Develop vocabulary about science



- 6a: Care vocabulary focus or words
- 6b: Show words in parts
- 6c: Use pupils' words in text and comprehension
- 6d: Support pupils to develop writing skills

TEACHER NOTES

Macroscopic – what we can see

Add one teaspoon of sand and salt to water and stir gently. Note your observations.

Some of the mixture (the salt/sodium chloride) dissolved but the rest (the sand) did not dissolve.



© Shutterstock / BW Folsom

Sub-microscopic – smaller than we can see

Choose the correct term to complete the sentences:

Salt is in the **solid** / **gas** state. The particles are **close together** / **far apart**.

Water is a **solid** / **liquid**. The particles are in **a fixed position** / **able to move around**.

When salt is dissolved in water, the salt particles **move together** / **spread out** to form a salt solution.

In the salt solution the salt particles are **evenly spread** / **all in one place**.

Symbolic – representations

Identify the solute, solvent and solution in the diagram below:



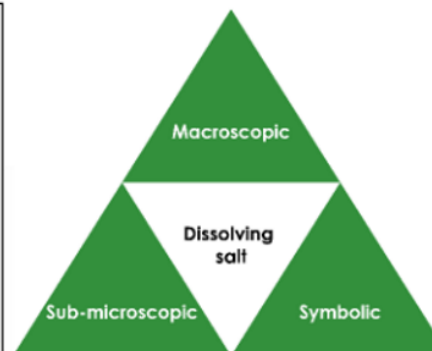
Solute: **salt**

Solvent: **water**

Solution: **salty water**

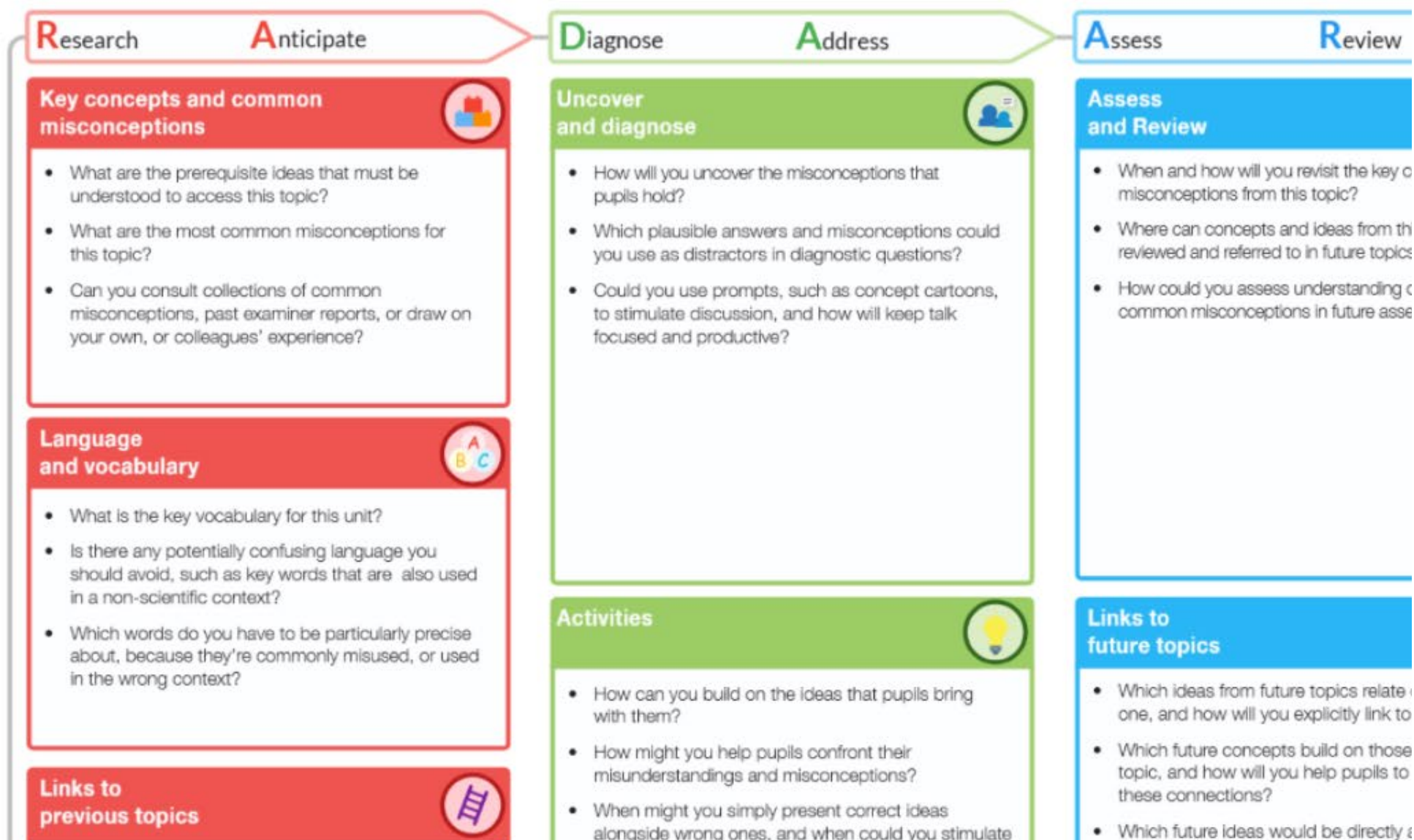
Johnstone's triangle 11–14 years

Available from [rsc.li/422BP92](https://www.rsc.li/422BP92)



IMPROVING SECONDARY SCIENCE

RADAAR Planning Logic diagram



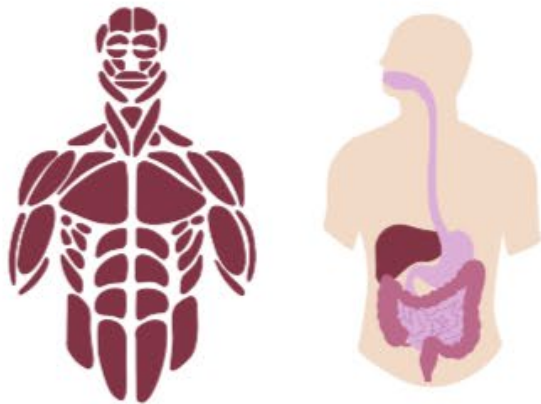
DIGESTION

Research and Anticipate



Anticipate potential hurdles

When children picture the inside of the human body, they tend to think we only have muscles on our limbs.



Children often think that digestion is a simple process, and don't appreciate the stages involved. They might think the digestive system only includes the mouth and stomach, and don't recognise our intestines are part of it.



Misconceptions in younger children

Check for understanding and build on the ideas that students bring to lessons. Younger children often think that:

Food stays in our bodies

All fat is bad for us

Use the RADAAR framework to support curriculum planning, building on the ideas that

Diagnose and Address



Diagnostic question

Food we swallow moves through the digestive system. Ask pupils which of these causes it to move through the digestive system:



A Gravity

B Contracting muscles

C Body movements (e.g. walking)

D Swallowing more food to push it along



Building on ideas

Take time to find out what your students think; allow them to discuss their ideas and reasons. Find ways of uncovering and addressing these misunderstandings.

People talk about
walks 'keeping you



Children find it easy
to imagine food
being pushed along
by swallowing or



Ex

An apple in a so
through the dig
model itself.

What does the
apple represent

What does the
sock represent

What do the
stripes on the so
represent?

Being explicit a
thinking. Invitin
can give them e



A secure unders
foundation for p
products are use
that it's digestio

A Model for Great Teaching

1. Understanding the content

- | | | | | | |
|----------|--|----------|---|----------|--|
| 1 | Having deep and fluent knowledge and flexible understanding of the content you are teaching | 2 | Knowledge of the requirements of curriculum sequencing and dependencies in relation to the content and ideas you are teaching | 3 | Knowledge of tasks, activities, and their dependencies; understanding of the potential for varied representations of content; and examples of effective teaching |
| 4 | Knowledge of common student strategies, misconceptions and sticking points in relation to the content you are teaching | | | | |

2. Creating a supportive environment

- | | | | | | |
|----------|---|----------|--|----------|--|
| 1 | Promoting interactions and relationships with all students that are based on mutual respect, care, empathy and warmth; avoiding negative emotions in interactions with students; being sensitive to the individual needs, emotions, culture and beliefs of students | 2 | Promoting a positive climate of student-student relationships, characterised by respect, trust, cooperation and care | 4 | Creating expectations and high standards; ensuring that learners are motivated and engaged; and responding to learner needs or failure to change |
| | | 3 | Promoting learner motivation through feelings of competence, autonomy and relatedness | | |

3. Maximising opportunity to learn

- | | | | | | |
|----------|---|----------|---|----------|---|
| 1 | Managing time and resources efficiently in the classroom to maximise productivity and minimise wasted time (e.g., starts, transitions); giving clear instructions so students understand what they should be doing; using (and explicitly teaching) routines to make transitions smooth | 2 | Ensuring that rules, expectations and consequences for behaviour are explicit, clear and consistently applied | 3 | Preventing disruptive behaviour; responding positively to learner needs; and ensuring that all learners are engaged and motivated |
|----------|---|----------|---|----------|---|

4. Activating hard thinking

- | | | | | | |
|----------|--|----------|--|----------|--|
| 1 | Structuring: giving students an appropriate sequence of learning tasks; signalling learning objectives, rationale, overview, key ideas and stages of progress; matching tasks to learners' needs and readiness; scaffolding and supporting to make tasks accessible to all, but gradually removed so that all students succeed at the required level | 2 | Explaining: presenting and communicating new ideas clearly, with concise, appropriate, engaging explanations; connecting new ideas to what has previously been learnt (and re-activating/checking that prior knowledge); using examples (and non-examples) appropriately to help learners understand and build connections; modelling/ | 3 | Questioning: using a range of question types to elicit responses; using higher order questions to elicit evidence of understanding; and using questions to assess learning |
|----------|--|----------|--|----------|--|

Best Evidence Science Teaching (BEST) INTRODUCTION

The best teaching draws on the best evidence.

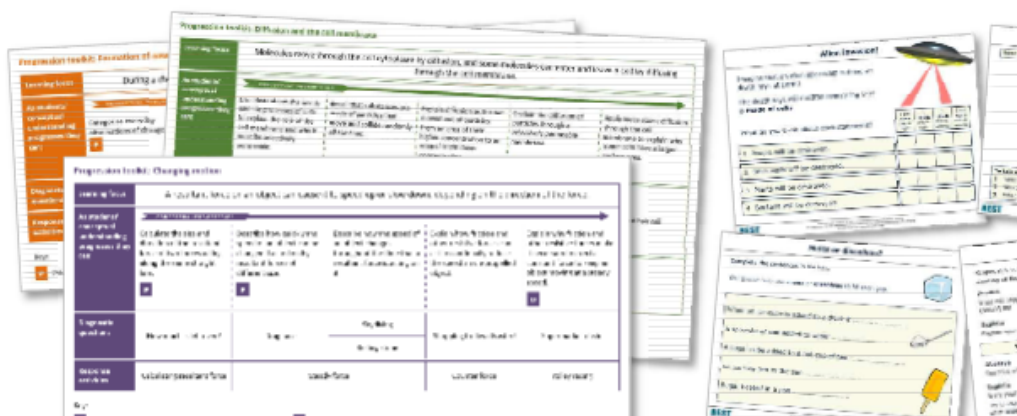
Best Evidence Science Teaching (BEST) provides a large online collection of **FREE** resources for secondary school biology, chemistry, Earth science and physics. The resources help teachers to build and consolidate students' understanding of key concepts in science, to facilitate better learning. The resources have been developed from the best research evidence we can find on common misconceptions in science, effective diagnostic questioning and formative assessment, constructivist approaches to building understanding, and effective sequencing of key concepts.

The BEST project aims to transform science education research into practice by making high quality, informed resources freely available to science teachers. It is not a commercial venture. The resources are developed by the **University of York Science Education Group**. We've published hundreds of resources for age 11-14. Resources for age 14-16 are being published on a topic-by-topic basis throughout 2021 and 2022.

The **Salters' Institute** has been proud to fully fund the BEST project since it began in 2010. The **Institute of Physics** is now a co-funder of BEST, having supported the project since 2017.

We are providing free online access to the resources in collaboration with **STEM Learning** for science teaching. Download from: www.BestEvidenceScienceTeaching.org.

The BEST resources



THE PRINCIPLES OF INSTRUCTION

TAKEN FROM THE INTERNATIONAL ACADEMY OF EDUCATION

This poster is from the work of Barak Rosenshine who based these ten principles of instruction and suggested classroom practices on:

- research on how the brain acquires and uses new information
- research on the classroom practices of those teachers whose students show the highest gains
- findings from studies that taught learning strategies to students.

Copyright

HOW2
teachinghow2s.com

01 DAILY REVIEW



Daily review is an important component of instruction. It helps strengthen the connections of the material learned. Automatic recall frees working memory for problem solving and creativity.

02 NEW MATERIAL IN SMALL STEPS



Our working memory is small, only handling a few bits of information at once. Avoid its overload — present new material in small steps and proceed only when first steps are mastered.

03 ASK QUESTIONS



The most successful teachers spend more than half the class time teaching, demonstrating and asking questions. Questions allow the teacher to determine how well the material is learned.

04 PROVIDE MODELS



Students need cognitive support to help them learn how to solve problems. Modelling, worked examples and teacher thinking out loud help clarify the specific steps involved.

05 GUIDE STUDENT PRACTICE



Students need additional time to rephrase, elaborate and summarise new material in order to store it in their long-term memory. More successful teachers built in more time for this.

06 CHECK STUDENT UNDERSTANDING



Less successful teachers merely ask "Are there any questions?" No questions are taken to mean no problems. False. By contrast, more successful teachers check on all students.

07 OBTAIN HIGH SUCCESS RATE



A success rate of around 80% has been found to be optimal, showing students are learning and also being challenged. Better teachers taught in small steps followed by practice.

08 SCAFFOLDS FOR DIFFICULT TASKS



Scaffolds are temporary supports to assist learning. They can include modelling, teacher thinking aloud, cue cards and checklists. Scaffolds are part of cognitive apprenticeship.

09 INDEPENDENT PRACTICE



Independent practice produces 'overlearning' — a necessary process for new material to be recalled automatically. This ensures no overloading of students' working memory.

10 WEEKLY & MONTHLY REVIEW



The effort involved in recalling recently-learned material embeds it in long-term memory. And the more this happens, the easier it is to connect new material to such prior knowledge.

Improvement resources

assessment

Q

211 result/s

Sort by Relevance

Filters

Sector

Tags

Type

Any type

Additional Resource

Annual Report

Effective Practice

Podcasts

Supplementary guidance

Thematic Report

Year

Effective practice 03/09/2024

Resources and assessments to support the development of pupils' numeracy skills

Effective practice 24/07/2024

Using effective assessment strategies to improve pupils' engagement, outcomes and understanding of how they learn.

Effective practice 08/02/2024

The progress of learners as a result of robust assessment strategies and monitoring of pupils' achievements and next steps in learning.

Effective practice 24/01/2024

Embedding assessment processes into school life so that the feedback ensures that pupils make strong progress in their learning.

Effective practice 29/07/2020

Improving marking and assessment through pupil participation

Effective practice 02/10/2018

Assessment for Learning and thinking skills

Science Capital Teaching Approach (UCL IOE)

Eight dimensions of science capital

A student's science capital can be grouped into eight dimensions:

1. Scientific literacy: a student's knowledge and understanding about science and how science works. This also includes their confidence in feeling that they know about science.

2. Science-related attitudes, values and dispositions: the extent to which a student sees science as relevant to their everyday life.

3. Knowledge about the transferability of science: understanding the utility and broad application of scientific skills, knowledge and qualifications.

4. Science media consumption: the extent to which a student engages with science-related media including television, books, magazines and internet content.

5. Participation in out-of-school science learning contexts: how often a student participates in informal science learning contexts, such as at science museums, science clubs and fairs.

6. Family science skills, knowledge and qualifications: the extent to which a student's family have science-related skills, qualifications, jobs and interests.

7. Knowing people in science-related roles: the people a student knows (in a meaningful way) among their wider family, friends, peers and community circles who work in science-related roles.

8. Talking about science in everyday life: how often a student talks about science with key people in their lives (e.g., friends, siblings, parents, neighbours, community members).

'Tweaked' lesson plan

Teacher Activity	Student Activity	
Students (individually, or in pairs) make sounds any way they like. They could choose to play an instrument (if some are available), sing, clap, beatbox, hum, drum, stamp etc. Build on students' contributions and show varied examples on YouTube of cultural music making. Ask what all these forms have in common? Ask students to share their ideas about how sound is produced.	The lesson begins with students' varied cultural experiences and preferences for music-making being welcomed and valued. In their own words, they discuss what causes sound, and how they can hear it.	BROADENING WHAT COUNTS
Invite students to draw diagrams on mini-whiteboards to explain how sound is produced, using their own examples and ideas if they can. Value a variety of responses, and link their descriptions to the scientific terms of particles, vibration etc.		ELICITING, VALUING AND LINKING
Give students a conundrum that will appeal to their particular interests (or let them choose). For example: "Can you remember if you can hear when underwater?" or "In movies set in space, you often hear spaceships 'zoom' away – why is this wrong?" Drawing on their answers to the conundrums, ask students to vote on whether they think sound travels best in solids, liquids or gases. Have students work in pairs – one student taps on table and other student listens to how the tap sounds. The student then taps the table again with same force, however second student now presses ear against table when listening for the tap.	Students recognise the value of science for explaining everyday phenomena. Students use their new ideas about sound and particles to predict and explain.	PERSONALISING AND LOCALISING BUILDING THE SCIENCE CAPITAL DIMENSIONS
Ask students for what sort of jobs / activities might it be useful to know about how sound travels? (Discuss DJ-ing, sound recording, working at sea) Ask if any students are involved in producing their own music and use special equipment or software to do so. Slinky demonstration – with a (sensible) student demonstrate how longitudinal and transverse waves look using a Slinky. Homework: Talk with friends and/or family about the quietest part of their home, school, or a local building. In half a page (with diagrams) explain why it is quieter and how the sound is reduced?	Students learn the difference between transverse waves and longitudinal waves. Students engage in science-related talk with friends and family. They learn about the acoustic features of a familiar building.	BUILDING THE SCIENCE CAPITAL DIMENSIONS BUILDING THE SCIENCE CAPITAL DIMENSIONS