Cognitive Science and TAPS

Guidance from the Teacher Assessment in Primary Science (TAPS) project

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Cognitive science

The influence of cognitive science has been increasing in recent years, with the hope that research in psychology (observing behavior) and neuroscience (observing the brain) can provide insights into learning that will inform practice in education. As noted in the latest review from the Education Endowment Foundation (2021), laboratory based experiments may be difficult to translate into the classroom, so there is now more of a focus on consideration of applied cognitive science research. Although this too can be difficult to generalise, due to the complexity inherent in classroom interactions. Nevertheless, there is a growing consensus that cognitive science can help us to reflect on teaching practices. This booklet will explore strategies based on cognitive science and how these relate to primary science teaching and assessment, linking to examples from the Teacher Assessment in Primary Science (TAPS) project.

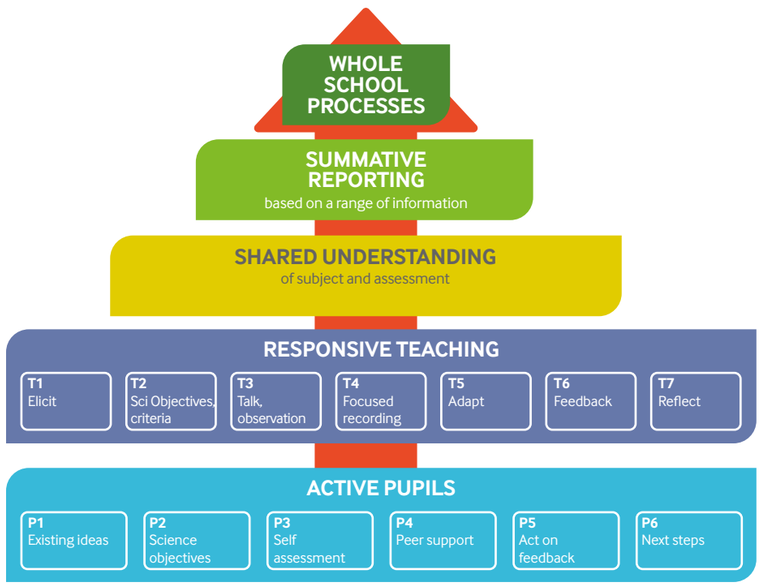
The dominant cognitive science model or theory of learning proposes that information is processed through 'working memory' and that this has limited capacity, so can easily be overloaded if there is too much information to process at once. The implication of this is that 'cognitive load' needs to be managed to support learners, especially when engaging with new information that they may not link together into 'chunks'. Clearly there are challenges here for how teachers can judge what the **cognitive load** will be for learners; formative assessment can help with this.

Another useful theory about learning is that longer term memory is built up as networks of connections or '**schema**'. Pupils build new ideas by reference to ideas they already have, with ideas linked together to form conceptual understanding. Cognitive neuroscience proposes that networks are built up over time with connections strengthened as knowledge is revisited. Schemas become more developed as knowledge is consolidated and elaborated upon. One implication of this is that there need to be opportunities for learners to both revisit content and deepen learning to develop more intricate schema. It also helps if teachers themselves have a good mental map (or schema) of how science knowledge fits together and how it can be organised into meaningful, but manageable chunks. In this way, teachers can manage their own cognitive load when teaching new content, as well as considering the likely cognitive load of their pupils. Well-structured medium-term planning anticipates the progressive steps that pupils may need to take, and builds in time to check their understanding and teach responsively.

Cognitive Science and TAPS

The Teacher Assessment in Primary Science (TAPS) project is based at Bath Spa University and funded by the Primary Science Teaching Trust. TAPS works together with teachers across the UK to research practice and develop resources to support the teaching and assessment of science in primary and early years settings.

A key principle for TAPS is that assessment is an embedded part of teaching and learning, whereby responsive teachers support their pupils to be active in their learning, with pupil outcomes useful for both formative and summative purposes. These principles are encapsulated in the TAPS pyramid model, which provides a framework, together with online examples, for schools to develop practice. In the TAPS pyramid, strong base layers of active pupils and responsive teaching underpin robust whole school science assessment processes. TAPS has also developed the Focused Assessment approach to support teachers and pupils to focus on one part of an enquiry at a time, within the context of a whole investigation.



Responsive teaching and Focused Assessment map closely onto cognitive science theories, with a range of linked examples particularly in the Teacher Layer of the TAPS pyramid. Most notably, the Focused Assessment approach, with its proposal to select one focus for attention within a scientific enquiry, can be explained in terms of how this helps to manage cognitive load.

Applying cognitive science principles to primary science teaching

Being aware of cognitive load	Strategies to optimise cognitive load to support new learning	Strategies to support remembering and deeper learning
Plan for new learning by considering science content and prior learning: • Explore the science content before teaching. (Subject knowledge resources such as ReachOut CPD can be useful for support). • Break down content into manageable chunks and think about the best sequence for those chunks. • Decide on the focus for the lesson and how this will be shared with the children - T2* • Consider prior knowledge and experience by planning opportunities for eliciting children's ideas and use this information help decide how to pitch the lesson - T1* • Consider other knowledge, skills and attitudes that may impact upon successful learning, e.g. pre-requisite skills to draw results table etc.	**Support new learning by introducing new content in a range of ways:** • Engage pupils' curiosity/interest and activate prior knowledge by discussing their ideas - P1, T1* • Demonstrate using concrete or worked examples. • Utilise multi-modal or multi-media learning, like dual coding for visual and verbal materials e.g. annotated diagrams, modelling digestive system - T3, T4* • Utilise embodied/experiential learning, whereby sensory practical experiences support learning e.g. feeling and describing the properties of materials etc. • Scaffold learning e.g. planning boards, question or sentence starters. • Focus any pupil recording on the learning aim – T4* • Use feedback from the children formatively e.g. pause for a mini-plenary to support or extend – T5, T6*	**Support development of secure and rich schemas by retrieval and elaboration:** • Continue to make links to activate prior knowledge e.g. discussing and drawing what is inside the human body - P1, T1* • Ongoing elicitation and retrieval practice – T3, T4* • Further develop ideas and connections by promoting deeper thinking e.g. discuss odd-one-outs from Explorify or explain to younger peers - P4* • Explicit links to topical science and their own experiences to build science capital - T3* • Revisit content over longer periods of time (spaced learning rather than 'massed practice'). • Provide opportunities for reflection on learning and metacognition – T7*

** link to Teacher and Pupil layer box examples on TAPS pyramid website*

REFERENCES AND RECOMMENDED FURTHER READING

Bell, D., Mareschal, D. and the UnLocke team (2021) UnLocke-ing learning in maths and science: the role of cognitive inhibition in developing counter-intuitive concepts, Journal of Emergent Science, 20, 19-26. Available here: www.ase.org.uk/resources/journal-of-emergent-science/issue-20/unlocke-ing-learning-in-maths-and-science-role-of

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Weinstein, Y. and Sumeraki, M. (2018) Understanding How We Learn: A Visual Guide. David Fulton/Routledge. A summary is available here: www.learningscientists.org/book

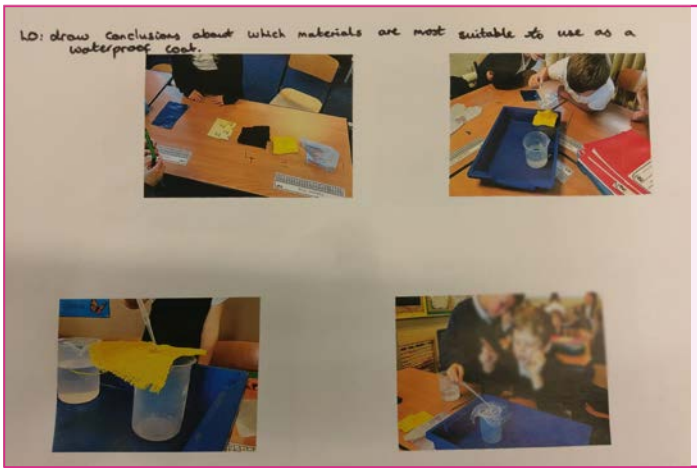
Examples of practice

T1 - Identifying existing ideas

A wide range of strategies can be used to elicit children's ideas. For example, class or group discussions, sorting activities, drawing diagrams, Explorify odd-one-outs etc.

These provide the opportunity for the children to activate their prior knowledge. For the teacher, they can identify starting points and any misconceptions that may impact the cognitive load experienced by the children.

T1



T2 – Focused objectives

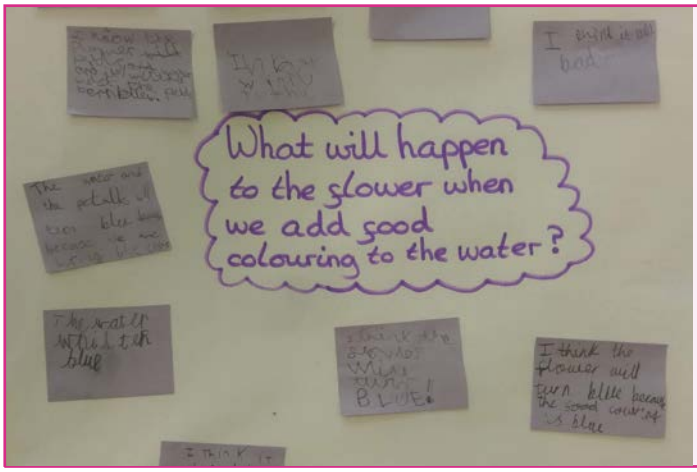
Having one element of Working Scientifically as the focus in an enquiry lesson helps to manage the cognitive load of practical activities. It also helps to direct observation and discussion with the pupils, supporting judgements about next steps. For example, when Year 2 pupils at Milton Primary School were investigating the waterproofness of different materials, the focus was on drawing conclusions. They planned the investigation as a class, carried it out in groups and then wrote brief conclusions (or were scribed for as appropriate). Further Focused Assessment lesson plans and examples can be found on the main TAPS website: pstt.org.uk/resources/curriculum-materials/assessment

T2

T7 – Time to reflect on learning

At St Fagans Primary, practical science lessons often follow a pattern of: engage, explore, challenge, apply, reflect. This lesson structure provides the opportunity for pupils to discuss and reflect a number of times during the lesson. This scaffolding breaks the lesson into chunks to support cognitive load, whilst also providing the opportunities for deeper thinking.

T7



T4 – Focused recording

Pupil recording (or teacher annotations for younger children) does not need to cover the whole of the enquiry process every lesson. It is better use of time to focus the recording on one element of enquiry such as predictions, graphs or conclusions. Having one element as the focus also helps to manage the cognitive load of practical activities. For example, at St Paul's Primary School the Year 3 'stem in dye' predictions were recorded on individual post its, whilst at St Edwards Primary School the Year 5 paper spinner evaluations are recorded individually in books. Across the year, different elements of Working Scientifically will be the focus and different recording techniques will be used.

T4

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