Using the 'Thinking Frames' approach to improve pupil engagement and attainment in science

National Teacher Research Panel
engaging teacher expertise

This summary was commissioned by the National Teacher Research Panel for the Teacher Research Conference 2006, which explored and celebrated teacher engagement in and with research. All conference materials are available at www.standards.dfes.gov.uk/ntrp

Aims

For Pupils

- Development of resources and approaches to challenge, engage and motivate pupils in science.
- Improving verbal and written explanations in science.
- Improving thinking skills and pupils' understanding of the nature of science.
- Raising attainment in science across all Key Stages.

For teachers

- Sharing practical resources to improve formative and interactive assessment techniques within science lessons.
- Assistance and guidance for teachers supporting systematic change in the school curriculum.
- Providing support and continuing professional development to assist teachers disseminating their findings e.g. through running staff INSET, publishing dissemination materials and delivery at conferences etc.

Dimensions of the study

The Cams Hill Science Consortium currently involves over 30 teachers from 27 different primary and secondary schools across Hampshire, East and West Sussex conducting trials and implementing our 'Thinking Frames' pedagogical approach. Hampshire and West Sussex Local Authorities have cascaded the Thinking Frames approach within their own training and it is now being used regularly in schools across these areas.

Summary of main findings

In schools where our 'Levels Mountain' and 'Thinking Frames' approaches have been implemented, there is evidence to show that:

- teachers' motivation has increased;
- teachers have seen an improvement in their pedagogic practices;
- pupils have acquired a greater sense of direction and purpose – they were tracking their own progression, and could see what they need to know to explain things;
- pupils' literacy skills and attainment have improved considerably within science at all Key Stages; and
- the Talking Frame provided an effective tool for 'interactive assessment' and pupil self- evaluation.

Background and context

The Cams Hill Science Consortium started in 2001 as a collaborative classroom-based action research project between six secondary schools funded by Cams Hill Schools Leading Edge Status. Securing additional funding meant that by 2005 we had expanded to become a network of six research groups involving 30 science teachers from a wide variety of primary and secondary schools. The generous support of Gatsby TEP, AstraZeneca Science Teaching Trust, Cams Hill Leading Edge Partnerships and Uplands Primary School's Beacon Status means that we are currently engaged in a variety of action research programmes seeking improvements in teaching and learning science across Key Stages 1,2,3,4 and post-16. We are also engaged in a variety of other projects including: looking at improving explanations across the different curriculum subjects; improving the interpretation of exhibits within an interactive science centre and challenging gifted and talented pupils within science.

Developing and refining our 'Thinking Frames' approach has involved us working in partnership with Local Authority Science Inspectors and Professor John Gilbert of The University of Reading and INTECH (an interactive family science centre in Winchester - www.intech-uk.com). Through workshops and follow-up support, teachers are guided in how to apply our methodology and provided with resources to conduct their own case studies, targeting specific issues affecting pupil progression in science within their schools. At the end of the 18 months of each project, teachers are offered support to present the findings of their case studies to our own dissemination conference.

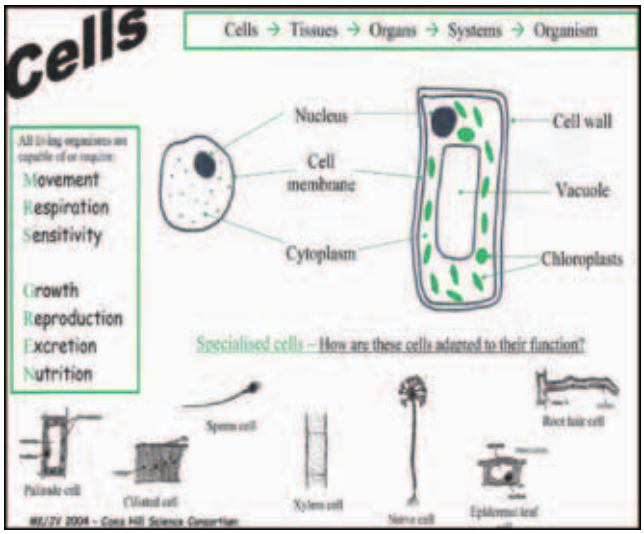
The findings presented in this summary are based on over twenty five different case studies covering all Key Stages carried out in Hampshire, East and West Sussex between September 2003 and the present.

Teaching processes and strategies

Although our work covered all Key Stages, what follows is a simplified account of suitable teaching processes and strategies for KS3. For further guidance please see our website www.thinkingframe.com.

A) Using the 'Levels Mountain'

First, teachers were encouraged to engage pupils in discussion in class using our Levels Mountain approach. This seeks to improve classroom debate and enable formative assessment and interactive assessment within the classroom. The Levels Mountain provides a visualisation of the thinking skills a learner needs in order to apply scientific models and modelling, so they can then form their own explanations as they progress through the school science curriculum. Teachers then produced their own versions of the Key Models placemats so that they took into account the models, descriptions and vocabulary



Example of a placemat designed to support the ideas of Cells by Court Moor School, Hampshire

that their pupils should be familiar with. Many schools laminated the placemats and pupils had them one between two on their desks at all times. Some enlarged them as well to make them into wall displays, or used them on interactive whiteboards via PowerPoint presentations.

When using the placemats to support the Thinking Frames approach, pupils were provided with access to all four Key Model Placemats and teachers were advised not to tell pupils which of the key ideas to work with, so that the pupils were required to make this decision. This meant that some pupils chose one of the models that did not explain the phenomena. However, pupils had the chance to learn from this process and then compare and adapt their explanations. Some teachers went on to use them to help pupils answer test style questions.

B) Using the 'Thinking Frame' approach

Some teachers found that the best way of explaining how to use thinking frames was to display one using an OHP, and then to go through a scientific problem step by step using the thinking frame as a reference. Teachers then encouraged their pupils to engage with the Thinking Frames; for example, many enlarged and laminated the Thinking Frames, getting pupils to work together discussing and debating the issue set, recording their ideas using a felt tip pen. Other teachers preferred to enlarge the sheets to A3 size and allow the pupils to write on them and consider them as disposable rough work. Of course, it was up to the teachers to plan the most appropriate approach for a particular group of children. As Thinking Frames support a process rather than a product-oriented approach, the pupils were under no pressure to complete all sections of the Thinking Frames every time that they used them.

'Brainwave' section

Pupils were encouraged to work together to write down all of the scientific vocabulary and ideas that they thought would be relevant to answering the question posed. They were encouraged to use the Key Models sheets for inspiration. When they had collated these they were then encouraged to share their ideas and prioritise the most important ideas / vocabulary.

See (Visualise) section

Pupils were encouraged to engage in producing their own models and/or modelling the processes involved. Pupils were encouraged to draw pictures and/or diagrams of the process that they thought was the cause of the phenomenon posed in the question; for example, after being shown a sunflower seed (which could be planted in March) and a full-grown sunflower (grown by September), pupils were set the question; "How did the sunflower get heavier?" In the 'See' box they were encouraged to draw stages in the growth process. Teachers explained to pupils that this section doesn't necessarily have right or wrong answers, but that the process of drawing helps us to think. Often what was needed was a sequence of three or more drawings showing snapshots in time through a process or phenomenon.

During this phase, teachers circulated round the groups assessing progress by talking with the pupils, encouraging them to discuss their drawings and annotating them with the vocabulary and ideas from the Brainwaves section. It is at this stage that teachers can begin to appreciate the root of any literacy difficulties that the pupils may have. At this stage, teachers could decide if pupils were having difficulty identifying and interpreting the relevant vocabulary, or whether they could visualise the process and apply the vocabulary in a new context.

Think / Sequence section

Here, pupils were encouraged to write down up to five bullet point statements that explained what was happening in their 'See' section. Using the sequence of diagrams showing snapshots in time within their 'See' section, pupils made a statement about each one. Teachers were advised to resist the temptation to correct the pupils if they got an incorrect sequence, as they needed to experience the difficulties for themselves.

Paragraph section

As in many cases, pupils were more familiar with writing paragraphs than using bullet points. It was sometimes unnecessary to complete this section, especially when the teachers judged that a sequenced list of bullet points was a satisfactory outcome, as is the case for both SATS and GCSE examination papers. However, we did recommend that pupils have regular opportunities to complete this section to meet the aim of improving their skills in forming paragraphs with sentences explaining abstract scientific phenomena and processes.

As pupils' literacy and confidence improved, they were encouraged to move on from the *Explain How* Thinking Frames to engage with the *Explain Why* style (see www.thinkingframe.com), which requires a more detailed written explanation. Within their lesson planning, teachers were encouraged to think of opportunities to ask "Why" questions, not just "How" and "What" questions.

Findings

Evidence from the case studies indicated that:

- there was increased teacher motivation;

  "When I heard about the dissemination meeting, I pushed to go and see. Then, because I saw so much good stuff coming out of it, I thought it was stupid not to get involved. ---- (It) renews my enthusiasm each meeting. (I) get good ideas for improving teaching that are readily implemented"
  Michael Tanner, AST, Henry Beaufort School, Winchester

- teachers saw an improvement in their pedagogic practices;

  "It helps me to explain to the pupils much more easily, and in doing so, helps me to gain a clearer picture of where they are in their own understanding so that I can inform them how to progress"
  Gordon Jackson, Second in Science, Warblington School

- pupils were being given a sense of direction and purpose – they were tracking their own progression, and could see what they needed to know to explain things;

  "That's Ok because we have got the scientific words needed for a level 4 answer – what explaining have we got to do to get a level 5?"
  Y8 pupils The Vyne School Basingstoke

"No that can't be level 6 because he hasn't explained the particles in enough detail."
Year 9 booster class pupils, Priestlands School, Lymington

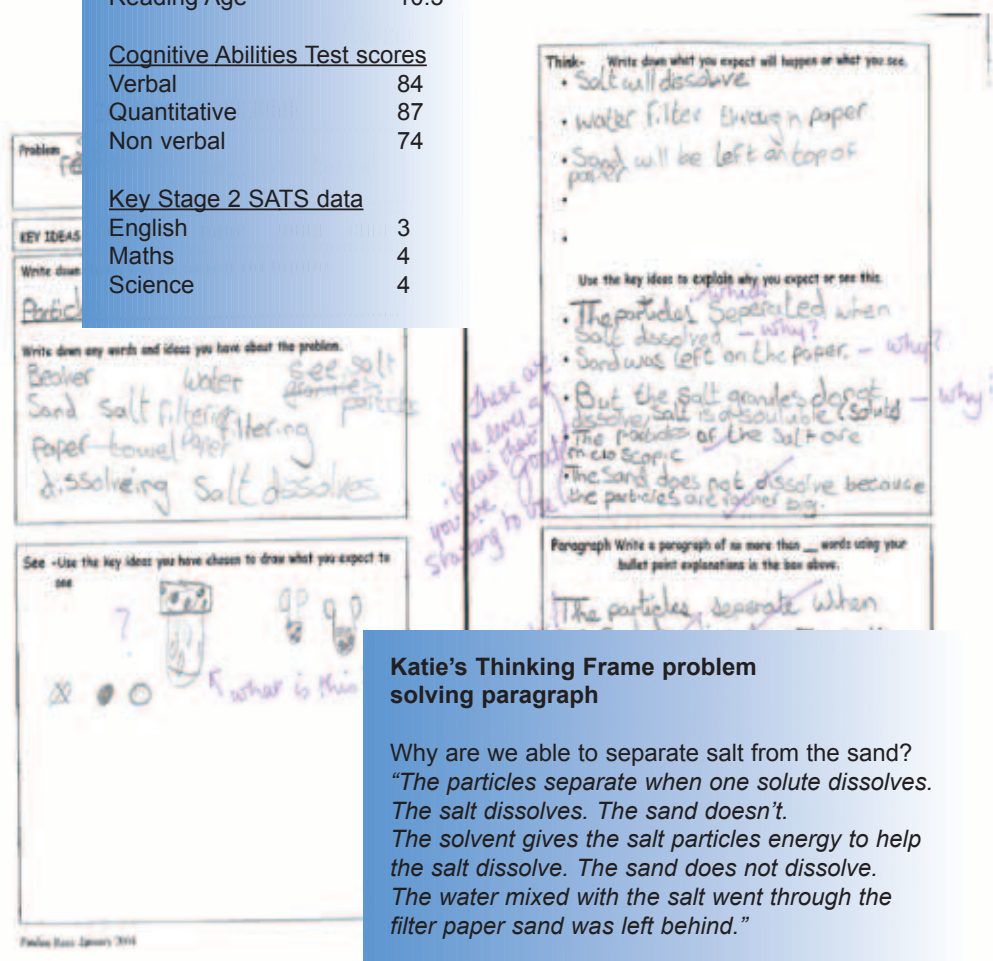
"I know that this has something to do with energy, but can you help me so that I can get a level 5"
Year 8 pupil, Neville Lovett School, Fareham

- pupils' literacy skills and attainment were improving considerably within science at all Key Stages; and
- the Talking Frame provided an effective tool for 'interactive assessment' and pupil self evaluation

Below is an example of work produced by "Katie", a Year 7, previously underachieving pupil with very low literacy skills and a previously low self-esteem. The January of Year 7 was the first time that Katie's group had used the Thinking Frames and the evidence shows that with the support of her teacher she has produced an explanation that shows clear progression in her achievement in both English and Science Levels.

Pupil data "Katie"

Calendar Age	11.6
Reading Age	10.3
Cognitive Abilities Test scores	
Verbal	84
Quantitative	87
Non verbal	74
Key Stage 2 SATS data	
English	3
Maths	4
Science	4



Katie's Thinking Frame problem solving paragraph

Why are we able to separate salt from the sand?
"The particles separate when one solute dissolves. The salt dissolves. The sand doesn't.
The solvent gives the salt particles energy to help the salt dissolve. The sand does not dissolve.
The water mixed with the salt went through the filter paper sand was left behind."

Research Methods

Our case studies typically took approximately 18 months to complete. Following negotiation with Headteachers and the teachers themselves, each member of the Consortium was supported to develop a portfolio of evidence. We offered materials and in-house support to conduct formative evaluations analysing materials such as: formative assessment / lift off tasks; pupil assessment data of this cohort and of previous years; feedback from lesson observations and OfSTED reports; sampling of pupils' work; and pupil interviews and teacher surveys. Following this process they were then supported to design their own approach towards meeting the specific needs of a targeted cohort of pupils within their school.

Each teacher attended a series of half-termly local workshops and meetings during which ongoing evaluation was enabled through discussion and debate with other teachers and the Directors of the Consortium. In later meetings, pupil achievement during the trials of the Thinking Frames approach was analysed in comparison to their individual prior attainment in National Tests, CAT Tests and prior teacher assessment. With over 30 teachers involved in our Consortium all sharing a common action research approach we have been able to collate trends and patterns within the data and outcomes of different individual case studies which used similar objectives and methodologies. This has enabled us to develop and refine the pedagogy and resources associated with the Thinking Frames approach.

Further reading

M. Newberry, M., Gilbert, J. & Hardcastle, D. (2005) Visualising progression through the science curriculum in order to raise standards, *ASE School Science Review*, 86(316) pages 87-96

Gilbert, J. & Boulter, C (2000) Developing Models in Science Education. City: Kluwer Academic Publishers
Gilbert, J. (2005) *Constructing worlds through science education* (The selected works of John K. Gilbert). Routledge

Contact details

The authors and the Cams Hill Science Consortium can be contacted via our www.thinkingframe.com

This publication has been supported by the DfES Innovation Unit
http://www.standards.gov.uk/innovation-unit

National Teacher Research Panel
engaging teacher expertise