Creativity in Primary Science: Illustrations from the classroom

Oxford Brookes University:
Primary Science Teaching Trust Academic Collaborators

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why& how?

PRIMARY SCIENCE TEACHING TRUST

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FOREWORD

"The work described here is not only highly accessible, it also develops a wide range of important key skills."

It is with great pleasure that I present a foreword for the work carried out by Oxford Brookes University under the auspices of PSTT. We have enjoyed a long association with this group and the work carried out has been excellent.

The Thinking, Talking, Doing project is a real jewel in the crown for PSTT, having been funded by an AZSTT (now PSTT of course) grant in 2002 and over the last 14 years has been shown to have significant impact in the classroom. The work is shown to improve SATs scores but of far more importance is the philosophy it engenders in both the young learners and their teachers. This project and its training is now being rolled out across the UK by Oxford Brookes University and will form part of the portfolio of training for the PSTT Cluster Programme.

Whether your lesson is creative in its exposition or engenders creativity is a fascinating but subtle distinction and yet carries significant implications for cognition. Sarah Frodsham's doctoral thesis challenges these ideas and preliminary data look set to shift our thinking in a positive way.

Drama has been shown to be extremely effective with a wide range of learners by a number of researchers, but the work described here is not only highly accessible, it also develops a wide range of important key skills.

We hope that you will enjoy the taster that this booklet provides and will want to find out more about the work described.

D Shallcross

Professor Dudley E. Shallcross

CEO, Primary Science Teaching Trust

1. INTRODUCTION

Our projects are designed to explore and evaluate creative practice(s) in primary schools.

Oxford Brookes University is delighted to be one of the teams of Academic Collaborators working with the Primary Science Teaching Trust.

There are two key themes of activity and enquiry that contribute to our unique identity at Oxford Brookes University and which are the focus of our work as Academic Collaborators:

- **Creativity**
  a. Defining it and promoting it.
  b. Exploring how it appears in learning.
  c. Developing, defining and sharing practice that supports it.
- **High quality thinking**
  a. Exploring how and when it supports learning.
  b. Developing and relating practice that supports it through creativity.

Our aim at Oxford Brookes University is to be a centre focused on the research and development of creativity in science education. We have generated a variety of approaches to support innovation and high quality thinking in the primary classroom. Our projects are designed to explore and evaluate creative practice(s) in primary schools, in Oxfordshire and beyond. We work alongside teachers supporting and enabling imaginative approaches to teaching and learning in science that are shown to inform professional development and have an impact on pupil engagement and attainment. Our work is research-focused and evidence-based so that teachers have confidence that the strategies we promote are tried and tested.

This booklet provides some insights into our work with illustrative examples that we hope teachers will find useful in their practice.

2. THINKING, TALKING, DOING SCIENCE

INTRODUCTION

The AstraZeneca Science Teaching Trust (now the PSTT) funded a two year project (2002 – 4) at Oxford Brookes University involving 16 Oxfordshire primary schools. Outcomes of this Conceptual Challenge in Primary Science project resulted in 32 teachers adapting their science lessons in the following ways:

- More emphasis on pupils' independent scientific thinking
- Increased time within lessons spent in discussion of scientific ideas
- More focused recording by the pupils so less but better writing
- More time for hands-on, practical investigations.

At that time, the Key Stage 2 science SATs were operational and this approach to teaching science resulted in a statistically significant difference to the pupils' results – they did better in the SATs.
So, in summary, a creative approach to primary science with an increased focus on thinking, doing and talking improved pupils' attainment (Mant, Wilson & Coates (2007).

In 2012 – 15, the Education Endowment Foundation funded Oxford Brookes, together with Science Oxford, to develop this work further in the Thinking, Doing, Talking Science project. The research design was a randomised controlled trial (RCT), with 42 participating schools and 1200 pupils Year 5 pupils (aged 9-10) involved. The RCT indicated there was a statistically significant impact on pupils' attainment, with a gain in their learning that was equivalent to three months of additional progress. In addition, the project pupils showed improved attitudes to science as a subject.

The full report can be found at:
educationendowmentfoundation.org.uk/evaluation/projects/thinking-doing-talking-science/

This is exciting and important, not only for primary practitioners, but also for policy-makers and head teachers. We are accumulating a body of evidence to illustrate how primary science teachers can develop creativity and enable pupils to enjoy learning science as well as improve their attainment. What follows includes a taster of the strategies that we developed together with the project teachers.

a. The bright ideas time

The Bright Ideas Time is a key strategy to encourage pupils to develop their thinking through talking. It is a dedicated discussion slot –time set aside to talk about science in each primary science lesson. It does not need to take more than 10 minutes and can take place at any point in the lesson.

It is a strategy that has been received enthusiastically by teachers in our various projects and they have given very positive feedback on its value in developing children's thinking and understanding. It is suitable for children of all ages and abilities.

> *The pupils find science a lot more fun, it's far more interactive, conversational.*

Teachers have found that this strategy is invaluable to elicit what pupils know and understand and consequently highlight their (alternate) or (mis)conceptions. It has also been used as an assessment tool.

The Bright Ideas Time is a module on the PSTT website and this gives full details, including video clips of teachers using the different strategies and the teachers' and pupils' views about how it works.

This is found at www.pstt.org.uk/resources/cpd-units/bright-ideas-in-primary-science

Various prompts have been developed for the Bright Ideas approach and three of these are given in this booklet. A sheet of further examples of each of these prompts, grouped according to age and topic, can be downloaded from the Bright Ideas module at the link above.

The children have a 'buzz' about science - very confident to express opinions, speculate and give justifications as to why they think as they do.

THE ODD ONE OUT

Our colleague, Mike Dennis, developed the use of the Odd One Out[1] whilst he was working with Science Oxford, to encourage pupils' thinking in science. This is the prompt that we recommend as a starter if people have not used the Bright Ideas Time previously. It is the easiest for the children to access at first.

The pupils are shown three or four different pictures, or better if possible the actual objects, and are asked to say which one is the odd one out and why. The 'why' is key – the pupils justify their reasoning and so reveal their thinking.

The example below is from one of the project schools, Freeland Primary School, and includes a sample of the pupils' responses.

There is no right or wrong answer and the children can be as creative as they wish (as long as they provide an appropriate reason). From these responses we can identify a common mis-understanding – the idea that a human is not an animal.

Also there is a good grasp of science illustrated by the child knowing that a bird is not a mammal. The '9 lives' may show a good sense of humour or another misapprehension!

The particular prompt chosen can be tailored to suit the lesson following and so this one could be used at the beginning of a lesson on animals. It is possible to pick up later on points made, such as 'Jamie said that the blackbird is not a mammal, do you agree?' 'What is a mammal?' 'Why is a bird not a mammal?'

Hippo because it lives in water.

The bird is the only one that is not a mammal.

Human is the only one not an animal.

Cat because it is the only one that has 9 lives.

THE PMI

De Bono[1] (1973) and Fisher (2000) are amongst the many who have developed methods to encourage pupils' thinking. The PMI is one of these. The pupils are given a scenario – a statement – and then consider, in turn with a few minutes on each:

P: **the Positives**
M: **the Minuses**
I: **the Interesting associated ideas**

An example from another of the project schools, St Andrew's Primary, with some pupil responses:

THE SCENARIO:

PEOPLE HAVE THEIR OWN PLANT-LIKE GREEN SKIN, SO THEY CAN CREATE THEIR OWN FOOD IN SUNLIGHT

Minus: You might not be able to lie still to sunbathe – you'd get a sugar rush and have to run around!

Positive: Poor people wouldn't starve.

Interesting: Would diabetes be a problem or not?

Interesting: Would you not need sleep?

These are obviously interesting and thoughtful responses, which show the pupils' existing understanding and also their ability to apply their understanding in a way that provokes further discussion. The teacher can decide whether these questions are pursued in this lesson or should be left for personal research.
Science is a creative subject and giving the pupils time to consider different aspects of a scenario, including the 'Interesting' ideas brings this to the fore – it allows their imagination to play a full part in science lessons.

[1]A lateral thinking technique originally suggested by deBono in 1973.

THE BIG QUESTION

In our opinion, the big questions 'lurk' in the curriculum, just waiting to be asked. If they are not asked, we miss an amazing opportunity to find out the depth of our pupils' thinking. Many teachers have said that they have been amazed at some pupils' understanding. This is often true of those otherwise labelled as 'low ability' – giving them an opportunity to express their understanding verbally is vital. It was revealing that the gain in conceptual understanding of the pupils of lower prior attainment was greater than for the project pupils overall.

More examples of big questions can be downloaded from the PSTT website and these are accompanied by some background subject knowledge so that no one need be afraid of asking such questions:

www.pstt-cpd.org.uk/ext/cpd/bright-ideas/the-big-question.html

An example from one of the project schools, Rush Common Primary School: 'Over time a seedling grows into a large tree.'

BIG QUESTION:

WHERE DID THE MASS OF THE LARGE TREE COME FROM?

Some pupil responses:

'The roots drink the water and eats the nutrients to keep it alive and helps it grow'

'The tree weighs more because of the food and water it has eaten in the past years. The tree doesn't have a mouth so the grass collects all of the food and water then it goes down to the roots also the tree likes rain better than house pipe water'

'The leaves suck in sunlight and convert into energy, using the chemical, chlorophyll. This process is called 'photosynthesis'

'It has come from the branches'

This sample of responses shows a wide range of understanding and illustrates how the technique is an excellent elicitation or assessment tool. It is also important though to use this strategy to help the pupils see that science is all about being curious. Einstein spoke of his own education and it could be argued that his comments are as pertinent for us today as they were then:

'It is, in fact, nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry; for this delicate little plant, aside from stimulation, stands mainly in need of freedom. Without this it goes to wrack and ruin without fail.'

b) The Practical Prompt for Thinking

The Practical Prompt for Thinking is a short teacher demonstration that tantalises the pupils and encourages them to think about the science behind what they have seen. They tend to be rather dramatic so that they attract attention and fire imaginations. Bridget Holligan and others at Science Oxford were key instigators in the development of a range of these prompts.

Example One: Balloon

Resources: *a lighter, one normally inflated balloon, a second identical balloon with some water in its base and then inflated (take care when adding the water to the balloon that you can find a tap with a spout that fits the balloon quite well! Remove the balloon from the tap when there is a couple of centimetres of water in it and then blow it up as normal).*

Ask someone (the head teacher?!) to sit on a chair in front of the class. Hold the normally inflated balloon over their head and touch the balloon with the lighter flame - it bursts. Hold the second balloon with the water in its base over the person's head and bring the flame up close. What will happen when the flame comes into contact with the balloon? Nothing happens – much to the relief of the head teacher, it does not burst. Why not?
In fact, the water conducts heat so well that it conducts the heat away from the rubber of the balloon and so it does not burst.

Example Two: The Seagull's Egg

Resources: *1 fresh egg, a straight, thin glass of tap water, a plastic tray, a jug of saturated salt solution (a saturated salt solution is one that has as much salt as possible dissolved in it. This needs to be prepared in advance and is achieved by having quite hot water and then adding spoonfuls of salt and stirring until no more will dissolve. Then allow it to cool and pour it through filter paper so that it is quite clear).*

Have the glass of water clearly visible for the class – perhaps raised on a small box. Tell the pupils that you are going to put the egg into the glass of water and ask them what they think will happen next. In fact, it sinks.
The shape of the glass means that the egg cannot be removed without also pouring the water out, so pour the water into the tray. This allows you to fill the glass again with the salty water from the jug, without the audience suspecting anything.
Now say that we want to turn the Hen's egg into a Seagull's egg. Obviously, a Seagull's egg needs to float - tongue firmly in cheek here of course! So how can we change a Hen's egg into a Seagull's egg? Well, obviously we have to flap. Ask the class to stand up and together do Seagull flapping motions, squawking etc.
Now place the egg into the glass and it floats. A round of applause is in order but how did that happen? Allow them time to think about this. A short time to 'think, pair, share' is very appropriate.
Once the answer has been arrived at, this could lead on to a lesson about dissolving or floating and sinking.

c) Practical Science and Focused Recording

INTRODUCTION

The project also had an emphasis on 'doing' science, with pupils undertaking a wide range of different types of science practicals, including problem solving and fair testing. Science is inherently a practical subject so the pupils really should be doing science in each lesson.
An important feature was that the pupils focused their recording on the learning objectives, trimming the time spent writing and releasing the time for thinking, talking and doing. However, the recording was sharp and focused and so it was a very effective assessment tool.

So, for example, if the pupils were finding out which is the strongest magnet, the learning objective might be 'to present the results in an appropriate manner', 'to plan a fair test' or 'to make a prediction with a scientific reason' and so whilst the pupils will do the whole practical, they only record what is necessary to demonstrate their progress towards that particular objective.

It is possible for the recording method to be very creative, whilst at the same time highly appropriate.

A FAIR TEST
WHAT DO YOU NEED TO MAKE THE BEST FILM CANISTER ROCKET?

Example from Stanton Harcourt Primary School who did this investigation with their Year 5 pupils, some of whose responses are included below.
Begin with a teacher demonstration of a film canister rocket – this can be with an Alka-Seltzer tablet (half a tablet is cheaper and works well) and water. Whilst most of us no longer use film cameras, it is possible to buy film canisters cheaply on line. Add about 1 cm of water to a canister and then add the tablet. Turn it upside down with the lid on the ground and retreat! This is best done outside.

It is possible to use fizzy Vitamin C tablets and water as an alternative. There are obvious health and safety considerations – such as warning them not to even think about eating the tablets, taking care to wash hands at the end of the investigation and moving away once the rocket is primed – they will fly high into the air. Careful supervision of each group is required throughout.
There are many ways of developing this as a fair test and below is just one example. The learning objectives in this case are:

- To make a prediction and to reflect on that in light of the results.

As a class discussion, ask them to think about what can be changed, what can be measured and what needs to be kept the same. There are various possibilities, such as changing the amount of water, keeping the same sized tablet and measuring the time taken for it to launch after turning the canister upside down. They could change the size of the tablet (a whole one, half, quarter etc.), keep the amount of water the same and measure the height the rocket reaches. The height measurement will need some discussion as the pupils must not be close to the rocket once the canister has been turned upside down, so it is likely just to be roughly how high up it goes, judged from a safe distance. Alternatively they could video the launches.

Then divide the pupils into groups and ask each group to make a prediction/hypothesis, examples from Stanton Harcourt Primary School were:

- The more tablet you use, the higher it will go.
- The more water there is, the quicker it launches.

They must record their prediction but there is no need for them to write out in great detail what they then do because that is not the focus of the learning objective. Discuss with them all how they can carry out their investigations safely and how they will record their results. They may need help thinking about what they will record and how – it would be good to help them draw up a sensible table. Again this is not the focus of the learning objective so they do not need to agonise over this and giving guidance is very appropriate. After the investigation, ask them to reflect on the results and to compare them to their prediction.

One group of pupils at Stanton Harcourt was able to disprove their hypothesis that using more water would make the launch happen faster.

They thought about this and learned that it was important to have plenty of space for the gas to expand so adding too much water did not improve the launch rate. The teacher noted that this was such productive learning.

The assessment is obviously not about whether or not their prediction was right, but on their reflection upon the results in light of their prediction, so that is what will need to be recorded.

PROBLEM SOLVING

Problem solving is open ended and is often best related to a real life situation, requiring the pupils to draw on their existing scientific knowledge and to use their imagination.

Below is a set of problem solving challenges linked to the electricity section of the curriculum that are differentiated and become progressively more challenging. The first one can be done successfully with quite young pupils. The pupils will need the electricity equipment and junk modelling materials, such as boxes, tubes, kitchen foil, card etc. The following are also useful: Aluminium foil (cooking foil), bare copper wire and insulated wire that can be stripped to make connections.

1. MAKE AN ALARM THAT COMES ON WHEN THE HAMSTER'S CAGE DOOR IS OPENED

No hamster needs harming in this process! The pupils learn that a hamster has learnt how to escape his cage and they need to use their electrical skills to help keep him safe. They use junk modelling materials to simulate a door – it's more challenging to design a system so an alarm comes on when a door is opened, rather than closed.

2. PROTECT THE PRECIOUS JEWEL

Tell them a story about a prince who inherits a precious jewel but it is so valuable that his insurance company tell him that it must be kept locked in the deepest vault, guarded by his best soldiers. The prince really wants his subjects to be able to see the jewel and enjoy its beauty so he calls on his scientific advisors to design a system by which it can be displayed safely – so, for example, an alarm might go off if it is moved.

3. MAKE AN ALARM THAT WARNS WHEN THE SHEEP RUN OUT OF FOOD

The sheep roam the hills and are in very isolated spots so it will really help the farmer if he can be alerted to the fact that the food trough has been emptied and needs refilling.

The culmination of each challenge can be a persuasive argument by each group of pupils as to why their product is the best – i.e. a sales pitch. There is much scope for imaginative work here and the pupils' recording can be via a set of photographs, video clips, PowerPoint slides etc.

3. DRAMA IN PRIMARY SCIENCE

INTRODUCTION

There are a wide variety of ways that dramatic strategies can be used to support learning in science. The module, Dramatic Science can be accessed on the Primary Science Teaching Trust website: pstt.org.uk/resources/cpd-units/dramatic-science

Some of the photographs (reproduced here with the publisher's permission) come from the book: Dramatic Science: Inspired ideas for teaching science using drama ages 5-11 by McGregor and Precious (2014).

The suggestions offered in this booklet include a few examples and can be classified as pedagogies that:

a. Support conceptual development

b. Support enquiry skill development

c. Engage children in thinking about scientists from history

a. Supporting conceptual development

To support children understanding concepts in science, they can be directed to enact different stages of a science process (like how electrical circuits work or how properties of materials affect their behaviour or what happens in germination). This is one of the most straight-forward and frequently used approaches. It is usually teacher directed although children can be invited to mime or model how they *think* something works and then the teacher (or others can suggest modifications or developments).

Figure 1: Teachers engaging in recreating a living model of a tree.

The children can be instructed how to move and speak to represent something in science. In Figure 1, teachers are practising how to build up and illustrate the way a tree is shaped and might grow. The 3D model of the tree is built up by first inviting the constituents of the 'trunk' of a tree, the 'heartwood' as it is often called. A circle of people can hold hands and chant the importance of the heartwood, "I support; I support; I support". Asking next, "How do trees obtain water?" can prompt a variety of responses, but hopefully someone will suggest 'roots'. A circle of people can then sit with their backs to the heartwood and have their legs out-stretched to represent 'roots'. The role of the roots is to absorb the water (through various processes including osmosis). The children can be invited to chant their role as roots, "I absorb water; I absorb water; I absorb water". The next part of the human model would involve the branches and leaves. These people could stand on chairs to connect one arm with the top of the trunk and the other outstretched (with the hand also outstretched)

Figure 2: Children engaged in modelling the parts of a tree (in this case a fir tree).

to represent leaves at the end of the branches. The chant that these parts of the model contribute, could talk about what they do as leaves and say, "I make food; I make food; I make food".

Another approach to help children understand scientific ideas is to represent them with a still model.

Figure 2 illustrates a group creating a representation of a fir tree (other groups could create shapes of different trees, such as willow, oak, chestnut and sycamore). Figure 3 shows children acting out (under teacher directions and without knowing) what happens in a wood when there is limit of nutrients, water or light for tree growth. After they have performed the sequence of events as instructed by the teacher, they had to suggest what it was they have acted out and explain their reasoning.

Reverse modelling is acting something out (following instructions) and then trying to work out what was demonstrated.

Figure 3: An example of reverse modelling. The children are enacting what happens when trees do not receive enough nutrients, water or sunlight.

Other examples of conceptual development might include:

Illustrating how germs can spread

Thinking about forces acting on toys (in this case a Jack-in-the-Box)

Chocolate before and after it has melted on a sunny window sill

Children developing their performance to show how shadows are formed

b. Supporting enquiry skill development

There are several ways in which this can be developed. One way is to use a monologue (or a story) of a scientist's life and development of their work. This can work as a way of introducing a scientist to the children –possibly one of whom they have not have previously heard.

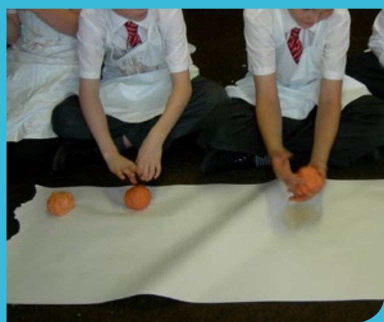
One example is William Harbutt, who invented plasticine in 1897. As an art teacher he wanted his students to be able to use a clay that didn't set hard too quickly before they had developed their sculptures etc. Having children listen to his story (or a teacher speaking as if him) highlights why and how the malleable clay came to be invented. The children can then work as a scientist-in-role as young Harbutts. They can be given water, flour, food colouring, oil and salt to create their own 'recipe' for modelling clay. Also, asking the children to 'document' their experimentation in exploring what combination of the ingredients works best, as well as then reviewing each other's, offers many opportunities for enquiry skill development.

Deliberating over how much flour, oil and water is needed

Having decided the combination, mixing the 'ingredients'

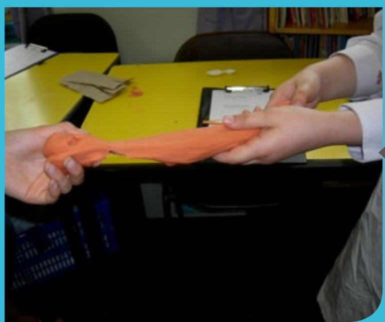
Adding food colouring and making the 'clay'

Setting out the different clays



Beginning to review each other's clays

Let the testing begin!



Through working in-role as a scientist the children say they:

- develop ideas;
- reflect on different proposals and suggestions;
- plan an experiment;
- systematically test ideas;
- obtain and present evidence;
- consider their evidence and what it means;
- solve practical problems;
- evaluate and communicate their inquiry to others;
- act like a scientist;
- feel like a scientist.

c. Strategies to engage with historical stories about scientists

Various combinations of drama pedagogies can be used to introduce children to stories about scientists from the past. The children can be 'hot seated' as the scientist; enact the role of a scientist in a mini-playlet; contribute to composing a 'tableau' or a series of still 3D poses that represent a scientist's skills or even 'sculpt' a scientist as a statue to be placed in a museum. One of the more unique ways we have developed is to use a monologue, that is a mini-speech given by teacher-in-role or a child-in-role (as if spoken by the scientist themselves).

HOT SEATING

Having been working-in-role as scientists, the children can be asked by the others :

- What did you find out?
- How did you do that?
- Why did you do it that way?
- Are there other ways you could have done it?
- What did you learn about being a scientist?

Figure 4: Hot seating.

ENACTING A SCRIPT

In Figure 5, the girl is acting as Mary Anning, trying to sell her shells and fossils to a couple walking along the Dorset-shire coastline.

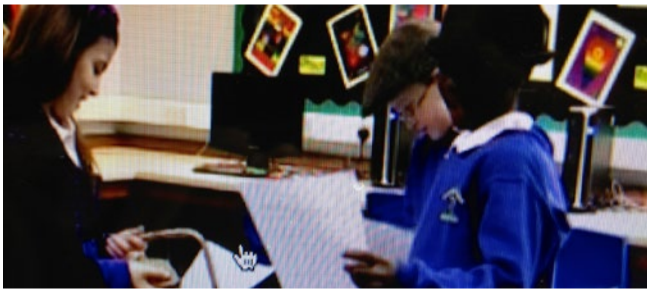


Figure 5: Enacting a script.

CREATING A TABLEAU

The group in Figure 6 were working collaboratively to create a composite picture of the skills that William Harbutt (the inventor of plasticine) possessed.

They were depicting his various skills, as a former teacher, sculptor, painter, father and business man.

Figure 6: Creating a tableau.

This approach can be used to create a tableau for any scientist that the children are introduced to.

MONOLOGUE

The teacher-in-role in Figure 7 is speaking as if Alhazan (who discovered light travels in straight lines whilst held in a prison). The children are listening intently because there are a variety of drama and science activities that will develop from this introduction to a scientist from history.

Figure 7: Monologue.

SCULPTING A SCIENTIST

This is a strategy that can be carried out for any scientist. It could be for a museum. In Figure 8, one of the boys is the sculptor, the other is being 'shaped' as Issac Newton.

Figure 8: Sculpting Isaac Newton.

4. RESEARCH IN PRIMARY SCIENCE EDUCATION

INTRODUCTION

We are passionate about providing evidentially-based good practice and our research covers a number of key areas (already outlined in the previous sections of this booklet) as well as the examples set out below.

a. Innovative technology in Primary Science

In recent years a considerable number of primary schools have started using tablet computers, usually iPads, for teaching and learning. Staff in the School of Education have been researching and developing ways of using tablets which allow children to capture and reflect on scientific and mathematical investigations. A common 'problem' with primary based science investigations is allowing children to capture information about scientific processes. Often children are asked to write recounts and reports after a science investigation – this can prove difficult as at best scant notes have been made and recalling with sufficient depth of detail relies on memory.

Our approach has been to develop use of one particular iPad app, Explain Everything, to 'record' investigations and science processes by capturing images and video. This app then allows children to annotate their information with text, symbols, graphics and audio annotation. Explain Everything was originally designed as a presentational tool – however education has embraced the intuitive interface for a range of pedagogical applications in the classroom.

During science investigations children are able to quickly capture video, audio and images – then annotate with text and audio (Figure 9). This allows children to capture science processes such as boiling water, making solutions or forces – and then reflect immediately on what they have seen. Primary age children have previously found textual recording of science processes frustrating in that they have found it difficult to capture detail and complexities. One benefit from this approach has been that children have been able to look at their records of investigations with sufficient time for reflection about what was happening. This has led to better recounts, questioning and a greater depth of understanding.

Figure 9: Annotating the photographs of the experiment on the ipad.

Mobile technologies such as iPads can enable intuitive ways of capturing a range of modes of communicating. They also allow children to move around, plan how they want to capture information and then easily share with their peers. We have worked with a number of schools to develop these approaches – with an increasing range of examples of impact on science investigations

Figure 10: Children capturing the movement of the shoe on the ipads.

Our research study of this approach has begun to show evidence of positive impacts on children's thinking and levels of understanding. Our study, still in a pilot phase, has audio and video recorded children's' activities whilst conducting science investigations with and without using Explain Everything on the iPad. Our main focus has been on the nature of dialogue during these activities – some interesting comparisons can be made between iPad and non-iPad use.

Figure 11: Children refining their experimental report through jointly capturing their ideas on the tablet.

b. Exploring the impact of storytelling

A very recent research development at Oxford Brookes University involves looking at the creative ways storytelling can be used for teaching and learning. This project has involved working with a professional story-teller to evaluate and develop materials that could be effectively used by teachers in primary science

Storytelling can take a wide variety of forms, from just 'reading' or 'relaying' a story to having children interact in various ways (by 'being' a character or 'acting' like someone or something in the account or even projecting beyond the ending of the tale to suggest what might happen if....) in a future narrative.

Figure 12a illustrates the storyteller weaving a narrative about Isaac Newton as a little boy. And Figure 12b highlights how a Y2 child is trying out ideas and suggestions related to the things that Newton might have explored or done as a young boy.

Figure 12a: Storyteller.

Figure 12b: Child 'being' a character.

c. Defining creativity in practice

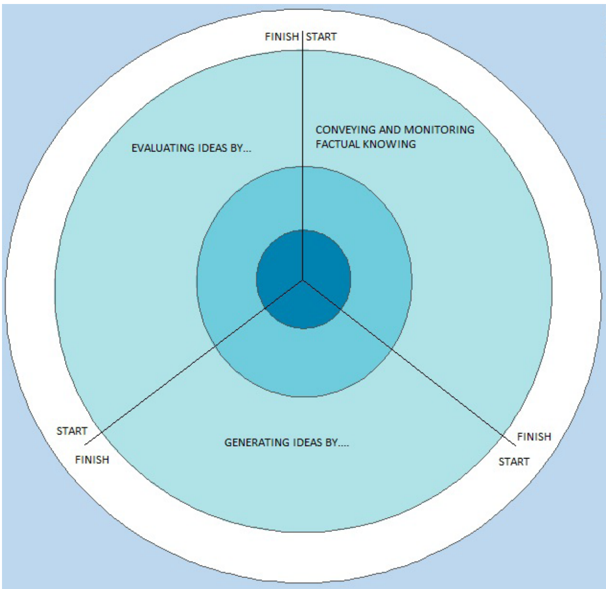
One of the ways in which the Primary Science Teaching Trust supports educational research at Oxford Brookes University is by providing funding for Ph.D. students. The University researchers then work with these students to consider different aspects of primary science teaching and learning in depth.

Sarah Frodsham has purposively selected local and national primary schools to assist her with her Ph.D. studies. Her research revolves around the development of creativity through the teaching of primary science.

She has constructed an analytical framework (see Figure 13) which captures the essential features of three teaching approaches, they are:

1) '**Expositional teaching**', otherwise known as direct teaching
2) '**Teaching creatively**' which focuses on the teacher and their ability to communicate science in as creative a way as possible
3) '**Teaching for creativity**' where the focus is on the creativity of the learners and the teacher's role is to teach in such a way as to enable the children to express and develop their creativity.

The three approaches are currently being applied to explore the ways that creativity emerges in classrooms. The analytical tool is being verified and triangulated with data collected from questionnaires and interviews. Once finalised it should help primary teachers reflect upon their approach to creativity in their science lessons.



Conveying curricular content and monitoring factual knowing or recall of subject matter	New	Questioning to check understanding in a different context.
	Conceptual	Questioning the ability to demonstrate active conceptual understanding.
	Task Specific	Questioning prior knowledge to demonstrate task specific understanding.
Offering opportunities for learners to generate original ideas	Taking risks	Suggests new novel ideas.
	Making connections	Sharing alternative ideas and forming links to expand upon them.
	Prior knowledge	Drawing on prior knowledge to see things differently.
Evaluating the thinking and creativity that may have arisen during the lessons/learning	Reflection for development	Teacher asks children to suggest ways of improving something the next steps for their learning.
	Critical/creative reflection	Asks children to critically or creatively reflect upon ideas and performance.
	Explained reflection	Asks children to reflect and expand on ideas and performances (task-led).
	Reflection (prompted)	Teacher reflects on potential ideas (task-led).

Expositional Teaching

Teaching Creatively

Teaching for Creativity

Figure 13 : A framework to visually represent creativity in teaching.

d. Reflecting on assessment of creativity

Sarah's research is also considering how current assessment practices may or may not augment the creative process. Assessment can be either:

- **summative** - usually a formal assessment at the end of a lesson, topic, term or school year to judge or assess what has been learned;
- **formative** - assessment that informs the learning cycle and usually engages the learner in assessing their own development (often referred to as Assessment for Learning or AfL).

Sarah's research focuses on the latter and how it can augment the development of creativity in primary school science lessons. To enable the successful, effective implementation and integration of formatively assessing creativity, Sarah is currently considering how the three following consecutive steps of AfL can enable the development of each individual learner's creativity. These involve children appreciating:

- what do I know? what can I do?
- what can I learn about next? what can I learn to do next?
- what should I do next to progress my learning?

If AfL strategies are applied only from the teacher's perspective there is a danger of learning becoming prescriptive that only informs the teacher about the children's 'stage' or progress in their learning.

To ensure assessment is mutually beneficial to both teachers and children it should be interactive in nature. Communications between learners and teachers (through written exchanges, dialogue, collaborative performances, etc.) are 'key' for each to appreciate progress and success. Different types of assessment strategies provide opportunities for the children to express their own reviews of their thinking and learning, share peer-to-peer or even collaboratively agree what is creative.

Sarah believes that there are differentiated steps towards achieving effective AfL, which can include:

- step 1 (teacher prescription)
- step 2 (child appreciation)
- step 3 (shared teacher and learner understanding about the child's progression that is mutually beneficial)

Figure 14 is an abstract representation of these three steps.

Figure 14 : A visual framework to suggest what kind of assessment arises through the three types of pedagogy suggested in Figure 1.

5. SUMMARY

This booklet provides a taste of some of the work we are engaged in at Oxford Brookes University.

It has provided some practical suggestions about ways to develop high quality, as well as creativity within primary science classrooms. The various activities outlined include :

1. Developing Bright Ideas, by asking children to offer scientific suggestions about things around them. These can be prompted in a variety of ways, such as inviting suggestions (and reasons) for the 'odd one out' or offering positive (P), minus (M) and interesting (I) perspectives on an aspect of science or asking big or significant questions that can be posed to engage them in thinking about something that might never have occurred to them before.
2. Presenting practical or visual stimuli to encourage thinking can engage them in discussing ideas and making predictions about what might happen next or they can be shown something surprising and asked to explain why it might have happened.
3. Ways to help 'focus' children's thinking and learning during practical science.
4. Using drama to support conceptual understanding, often through 'enacting' scientific processes.
5. Engaging children in carrying out enquiries as a scientist-in-role.
6. Using stories from historical scientists' lives to encourage appreciation of their work and relevance of their discoveries to the world around us.
7. Additional research into the use of tablets in enquiry contexts; the impact of storytelling; defining, enacting and assessing creativity.

The pedagogic strategies shared in this booklet have arisen from evidence-based-practice, or have resulted from research-to-inform-practice. There will be more to share in the future as our research activities develop.

We are always interested in working with teachers and other researchers to develop and improve creativity-in-practice and creative-learning so if anything related to our work outlined in this booklet interests you, please do get in touch.

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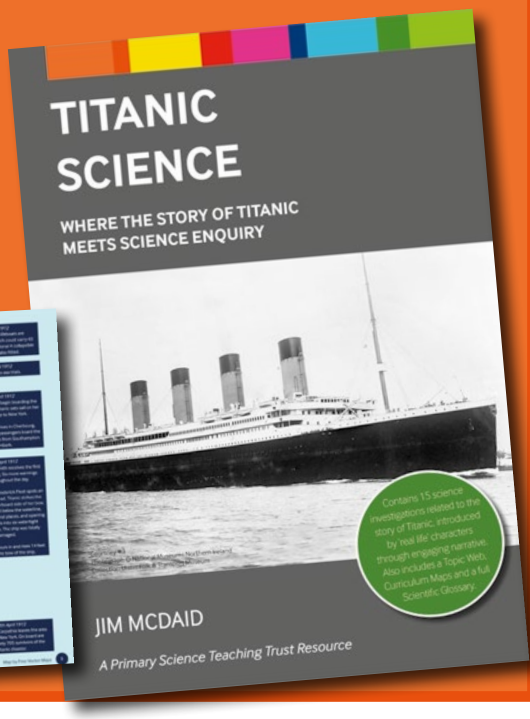

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