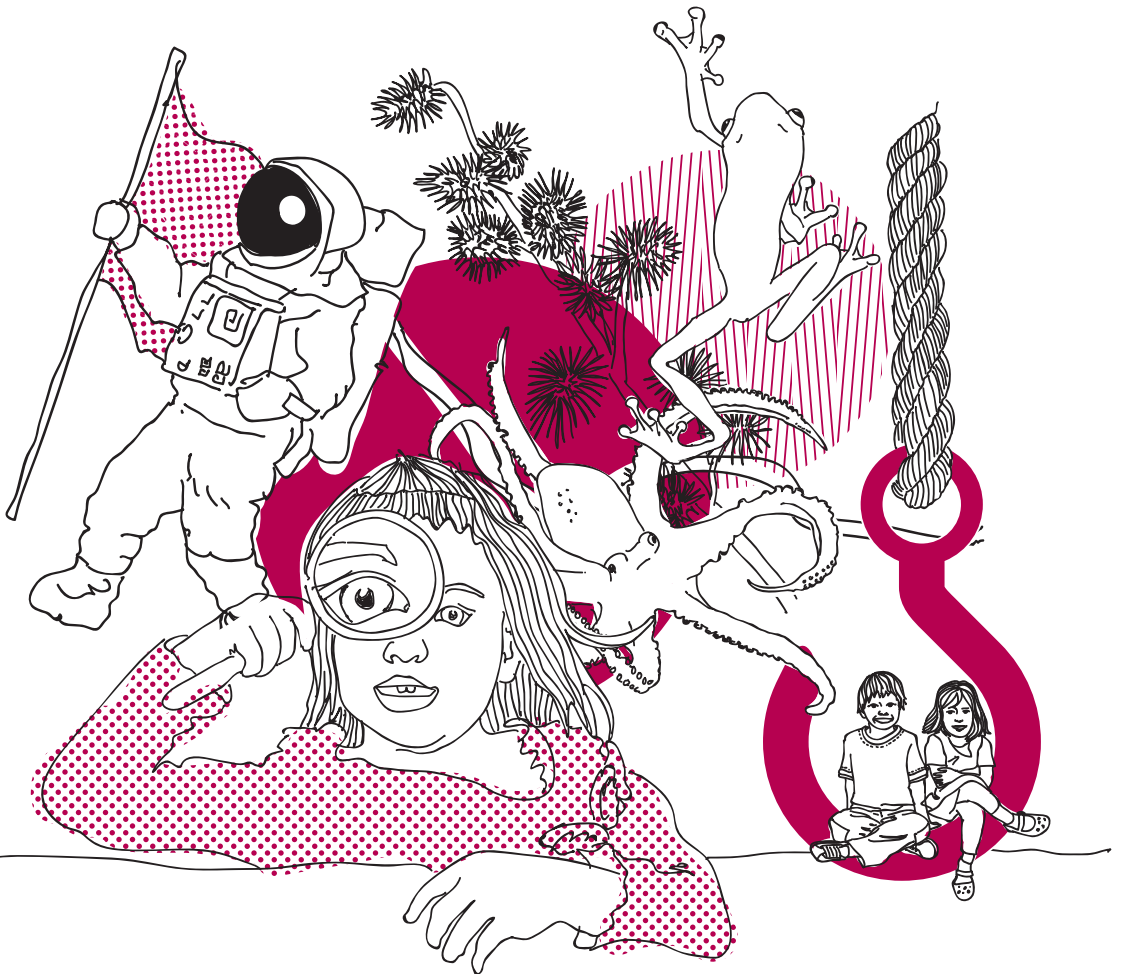


An A – Z Guide to Primary Science
Active Teaching And Learning
Approaches In Science

Dr Lynne Bianchi & Rosemary Feasey




Dedicated to Dr Eric Duckworth OBE
(Comino Trustee)

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This booklet has been produced to celebrate the 25th Anniversary of the original Active Teaching and Learning Project (ATLAS) which drew upon the expertise, experience and advice of teachers and educators from around the country in 1986. Much has changed in science education since then, yet many things have stayed the same.



For more information on the
Comino Foundation & its work
with us at Sheffield Hallam
University, log onto:
www.cominofoundation.org.uk
www.shu.ac.uk/research/cse

As with the original ATLAS material, this booklet has been guided by the same two simple principles:

1. That children learn best when they are motivated to learn, i.e. when they find the learning experience enjoyable and worthwhile and when they are actively involved in the learning process.
2. A teacher is likely to be more effective having first gained the confidence and skills to use a range of strategies which provide a variety of active learning experiences for the students.

This book has been supported by the Comino Foundation which has been a significant partner for the Centre for Science Education (CSE) over many years. Together we seek to promote the understanding of the process of achievement, so that through greater understanding of the nature of this process, people become:

- more focused on achievement;
- more attuned to achieving successful outcomes;
- more capable of achieving what they set out to achieve;
- better equipped to realise their own potential and to serve others.

How to use this booklet

The aim of this booklet is to provide a starting point for reflection and discussion on issues in primary science education, for example, it could be used:

- for reflection on your own approaches to teaching and learning;
- as a starting point for discussion with colleagues;
- to initiate debate within your own school or a family of schools.

Each section contains a summary of current ideas and some questions on which to reflect.

Collaborate with us at the CSE

The primary team at CSE would like to offer an open invitation to you to work with CSE whoever you are, whether you are a classroom teacher, senior manager, lead professional for science, consultant or in industry. If you would like to find more about CSE visit www.shu.ac.uk/research/cse.

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Acknowledgements are extended to Rosemary Feasey, Visiting Fellow of Sheffield Hallam University for her support in the writing and development of this booklet and to Tanya Shields for her special contribution to section T.

Active science learning has been a long standing trademark in the work of the Centre for Science Education as championed in the publication 'ATLAS – Active Teaching and Learning Approaches in Science' (1992). More recently Smart Science (2006) is a resource developed to exemplify how ATLAS could be further enhanced by infusing a range of Personal Capabilities within primary science learning.

There are many different ways to encouraging an active approach to learning. Consider how many of these strategies you currently use (ref. Figure 1).

Active learning takes place when pupils:

- have personal involvement in their learning
- make decisions about the outcome of their work
- discuss and work purposefully with others using scientific vocabulary
- plan and design their own activities
- test their own ideas to solve problems
- communicate to others
- ask questions that can be investigated and questions that can extend their learning
- think about, reflect on and evaluate what they are doing

Active learning takes place when the teacher:

- encourages children to take responsibility for their own learning
- challenges the children to think for themselves
- offers a wide range of learning opportunities
- uses a wide range of teaching strategies
- encourages independence and decision making
- offers children a wide range of audiences
- presents open ended situations
- thinks about the learning environment

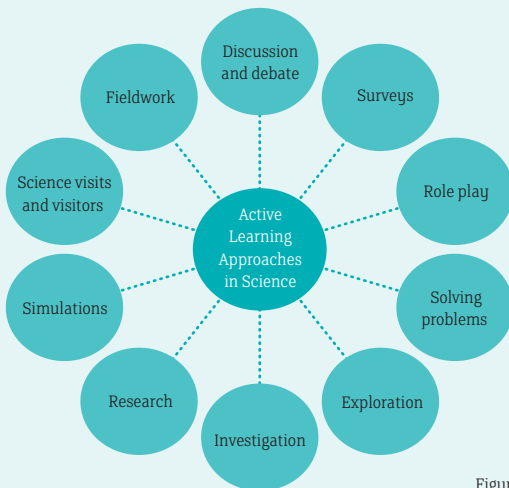


Figure 1 Approaches to active learning.



“ THE THREE RICHES
 PROVIDE A THREE STEP
 APPROACH TO PLANNING
 FOR ACTIVE LEARNING ”

Recently, we have extended the notion of active learning by exploring how best to develop ‘Rich Tasks’ – our way of best describing a contemporary form of active teaching and learning which leads to motivated teachers, innovative teaching and most of all **engaged** learners.

The Three-Riches approach will be explored further in this booklet. It provides a three-step approach to planning for active learning and generates activities that are:

- a) **Context-Rich:** they explore skills, knowledge and understanding through real and engaging topics or themes;
- b) **Activity-Rich:** they use a range of inspirational ideas and different modes of delivery such that children use a range of personal, learning and thinking skills, working independently, in pairs, in small groups, as a class, inside the classroom or outdoors; and
- c) **Response-Rich:** they encourage children to show their learning using a wide variety of new information and communication technologies.

Reflect on

Primary science has been developed on the premise that children should be offered ‘practical’ or ‘hands on’ opportunities in learning. Is being ‘hands on’ synonymous with being an ‘active’ learner?

- How do the range of approaches in Figure 1 support active learning in your classroom?
- Which approaches do you think could lead to added impact on teaching and learning in your science?
- What is your opinion of the Three-Riches approach and how it could influence your planning of science?

References, useful reading and links

- Bianchi L & Barnett R (2006) *Smart Science*, Sheffield Hallam University, Sheffield
- Bianchi L & Thompson P, *The Keys to Wonder-full Science Learning* (Chapter Pending publication)
- Sheffield City Polytechnic (1992) *Active Teaching and Learning Approaches in Science*, Collins London
- Smart Science URL – www.smart-science.co.uk

Many national curricula in science are founded on a collection of information, ideas and facts, often discretely taught, without offering the learner the opportunity to stand back and make sense of how interconnected science is and understand the bigger picture. Recently discussion in science education has begun to focus on developing a science curriculum that is based on the premise that teachers should work towards developing pupil's understanding of the 'Big Ideas' in science.

'The goal of science education is not knowledge of a body of facts and theories but a progression towards key ideas which enable understanding of events and phenomena of relevance to students' lives.' Harlen, W. (2010, p.2)

These key ideas in science, called 'Big Ideas', move science education towards making links between smaller steps en route to understanding a bigger idea. As pupils progress through their science education they 'make links that create bigger and more abstract ideas'. Harlen continues and suggests that if the Big Ideas approach is adopted then teachers will be, 'ensuring that the students arrive at a picture of the world that is not a collection of independent assertions but parts that connect with each other.' (ibid, p.47)

The Big Ideas:

- have wide-ranging explanatory power
- facilitate understanding of current issues that affect human health and wellbeing, the environment, the use of energy, etc
- provide pleasure in understanding and satisfy curiosity about the natural world
- have cultural significance in relation to human activity and its impact on the environment.

What are the implications of the Big Ideas for primary science education? The main implication is that teachers should think differently about what constitutes the subject knowledge to be taught and how to help children to understand that:

- what humans know about science changes over time
- people use science to create things
- when humans apply science there may be consequences and we have to think about ethics, politics, the economy and effects socially on people.

Reflect on

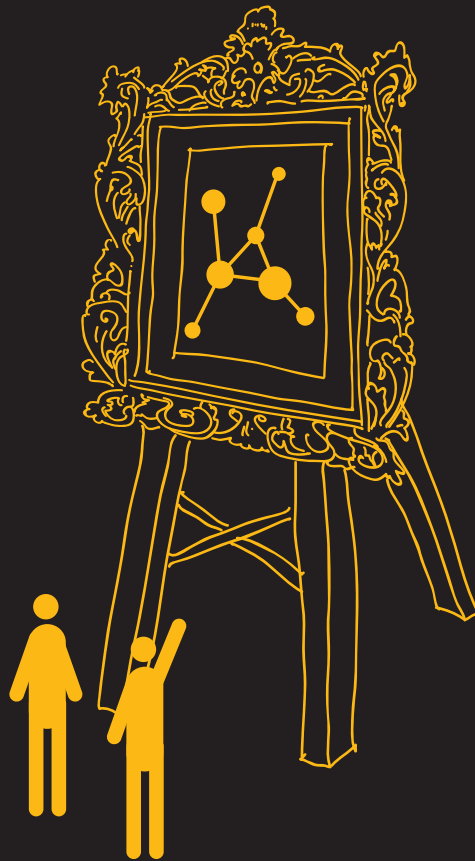
— What impact would teaching the 'Big Ideas' have on primary science in your school?

— Do you feel that your science subject knowledge and understanding, and that of your colleagues, could support this approach?

— What effect would the Big Ideas approach have on teaching and learning across the primary years?

References, useful reading and links

Harlen, W. (Ed.) (2010) *Principles and big ideas of science education*: ASE. Hatfield.



**LEARNERS NEED TO SEE HOW
SCIENCE IS INTERCONNECTED
AND TO SEE THE BIGGER PICTURE**

What do you think it means to have lessons or activities that are 'Context Rich'?

Why do the contexts through which we teach and learn science matter?

Relevant and interesting contexts get children hooked into primary science. If we offer contexts that children can't relate to then we run the risk of losing their interest before we've even begun, or indeed losing the opportunity to explore and connect to their intuitive understandings, beliefs and previously acquired knowledge and understanding.

Children learn when they develop new connections with what they already know or have seen. As teachers we should pay more than a notional lip-service to what children say they're 'into' and consider how science learning can be offered in ways that children see relevant to themselves and that they can identify within their daily lives and experiences.

Contexts are important because they challenge children to apply their scientific skills and understanding from familiar to novel or new situations.

Lemke, J.L. (1994) suggests that it is not enough to say that we approach 'science in everyday contexts', but that we must be explicit in what we mean by this and why contexts are important to children's learning, and how they support learning and when should they be used.

The range of contexts offered to children should include:

By giving children access to science set in a range of contexts, teachers can:

- provide practice in applying the fundamental concepts of science
- increase the level of sophistication of the way pupils think about their world
- improve children's awareness of the diversity and influence of science in the world around them.

In this way children become more scientifically literate – able to appreciate, use and apply science in a range of contemporary situations.

Reflect on

- How you would best find out about the contexts that appeal to the children in your care?
- What kind of contexts would staff feel confident in using?
- How should contexts change across the primary years?
- How could you develop 'Context Rich' science in your school?

problem solving

workplace

school based

scientists

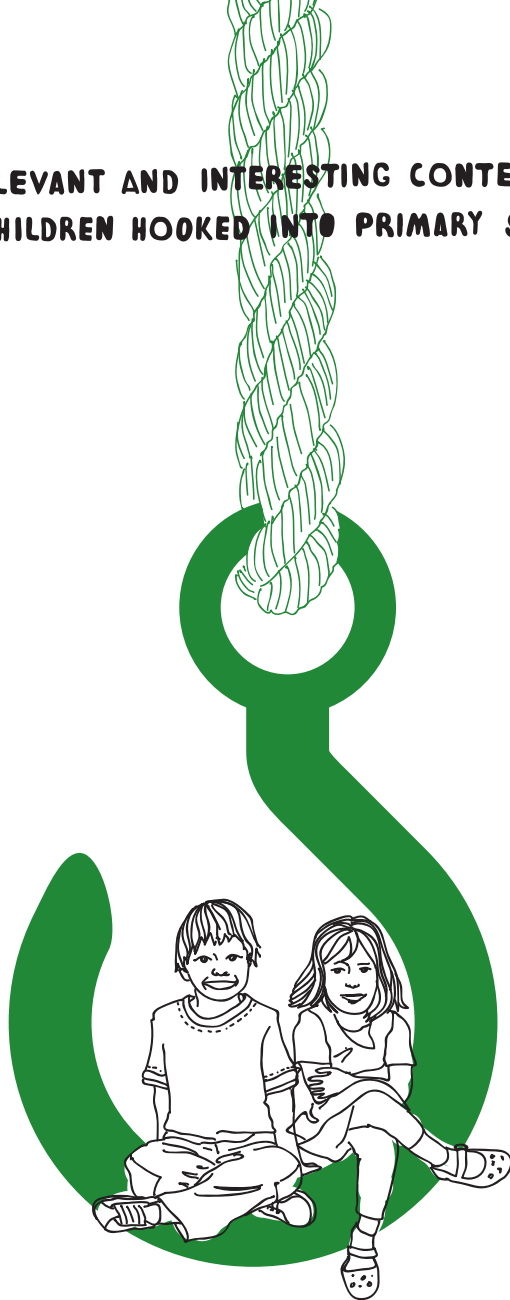
environmental

issues that involve themselves, society and the wider world

historical

role play

RELEVANT AND INTERESTING CONTEXTS GET CHILDREN HOOKED INTO PRIMARY SCIENCE



References, useful reading and links

The Missing Context in Science Education: Science J.L. Lemke City University of New York This paper was presented at a multi-disciplinary symposium "In Search of Inquiry" at AERA, Atlanta, GA (April 1992). Arlington VA: ERIC Documents Service (ED 363 511), 1994.

<http://dictionary.reference.com/browse/context> accessed 7.3.12

http://serc.carleton.edu/econ/context_rich/why.html accessed 7.3.12

D

Discussion and Debate

Discussion and debate are not the same; it is important to distinguish between the two in primary science, and in doing so it can influence how we support children in thinking and talking about science in different contexts.

Discussion – means to talk over something with someone else.

Debate – refers to discussions where people take opposing viewpoints.

Both discussion and debate are central to how scientists and the scientific community work; it is the basis of how scientists share and validate ideas and ways of working in science. It is also how they challenge each other to ensure rigour and integrity. Public discussion and debate about science is where people learn about how science influences their lives and may lead to the public having some influence on the work of scientists.

In the Cambridge Primary Review, Alexander (2010, p.29) suggests that ‘Talk – at home, in school, among peers – is education at its most elemental and potent. It is the aspect of teaching which has arguably the greatest influence on learning.’ He goes on to suggest that schools, ‘should be: where classrooms are full of debate and discussion that is collective, reciprocal, supportive, cumulative, critical and purposeful.’

Feasey, R. (2011) suggests that children working in primary science mirror how the scientific community works, so it is obvious that some, if not all of the purposes of discussion and debate amongst scientists are reflected in the classroom. For example, discussion and debate offer children opportunities to:

- share ideas
- challenge thinking and ways of working
- construct and re-construct meaning
- change ideas and approaches
- clarify understanding

Productive discussion and debate flourishes in a classroom climate in which:

- teachers and children respect each others ideas and opinions
- where ground rules are established for speaking and active listening

Discussion and debate demand that children develop and practice a range of personal skills and capabilities, including:

- structuring thinking and information
- collaboration, cooperation and teamwork
- listening (and hearing)
- responding
- understanding their audience.

Debating extends discussion as an active way of learning. Well planned debate in science requires children having researched and prepared what they want to say and that time has been given to underpinning arguments with evidence using scientific knowledge and understanding.

There are many different strategies to support children in discussing and debating in science, you might recognise some or all of the following examples.

- Hot topic of the day – a science news item from the media or based on Primary UPD8 (see page 46), children could be asked to suggest positives, disadvantages and things that are interesting.
- Listening triads – where children take the roles of speaker, questioner, recorder
- Snowballing – Pupils first talk in pairs to develop initial ideas. Pairs double up to fours to build on ideas. Fours double up to tell another group about their group's ideas.

Later on in this booklet you will be introduced to the techniques related to Verbal Behaviour Analysis (see page 48) – good discussion and debate rely on individuals being perceptive of those around them and using behaviours that enable them to manage conversations effectively. Read on to find out more about this area of work.



Reflect on

- What do you think are the benefits to children of engaging in discussion and debate in primary science?
- What changes to a classroom could be made to encourage discussion and debate?
- What approaches can you use or develop to help children to resolve differences of opinion when engaged in debate?
- How can discussion and debate be integrated into a scheme of work to ensure progression across the primary years in science?

References, useful reading and links

- Alexander (2010) *Introducing the Cambridge Primary Review*, University of Cambridge. Access online at www.primaryreview.org.uk/Downloads/Finalreport/CPR-booklet_low-res.pdf. Accessed 7.3.12.
- Feasey, R. (2011) in Skamp, K. (Ed.) *Teaching Primary Science Constructively 4th Edition* Melbourne: Thomson.
- www.azteachscience.co.uk/resources/cpd/talking-science/view-online.aspx
- www.azteachscience.co.uk/resources/cpd/discussions-in-primary-science.aspx

E

Evidence

Ask a child or group of children what they think the word evidence means and they will undoubtedly refer to criminal investigations, the police, court rooms and probably forensic scientists, for these are the contexts in which children come across this word and begin to build up their own concept of the word.

In some ways it can be very useful to parallel the exciting world of the forensic scientist and courtroom drama with evidence in science because in both contexts evidence is being used to support or counter an argument, hypothesis (giving reasons for what might happen) or a theory.

Whether a person is a thief, computer hacker or fraudster, the police evidence must prove beyond reasonable doubt the supposition. Science plays to similar rules, if a scientist observes something, has a theory, has discovered something then he or she must provide proof. It cannot be any old proof, it must be able to withstand scrutiny, it must be valid and reliable, just as the evidence of a witness in a courtroom must be able to stand challenge.

In order for children to appreciate the importance of evidence they should have an understanding of:

- scientific concepts
- the importance of standard measurement
- how the evidence was collected – whether the process was valid and the evidence reliable
- the link between the evidence and the question
- patterns and trends in data
- whether conclusions are appropriate to the evidence presented.

Children, just like the forensic scientist, will have a question or problem to solve, they will need to do something to collect evidence and use that evidence to answer their question, solve their problem, lead them to draw a conclusion. They should be able to present that evidence and have others, preferably their peers, challenge that evidence and their conclusions to find out whether they are robust, or weak. This is exactly what happens in the working world of a scientist, and it is thinking and working scientifically that we are asking children to emulate, and central to this is 'evidence'.

CHILDREN, JUST LIKE
FORENSIC SCIENTISTS
WILL NEED TO USE EVIDENCE
TO ANSWER THEIR QUESTIONS



Reflect on

- What do your children think the word evidence means?
- What do you know about children developing their understanding of evidence in science in your school?
- What kind of strategies would support children developing their understanding of evidence in science?
- How could children be exposed to the work of scientists both past and present to illustrate how the collection of evidence led to changes in science?

References, useful reading and links

TOLSON, S (2011) *Engaging critically with scientific evidence*, *Primary Science, Issue*: September 2011 119, Association for Science Education

Classroom based action research has demonstrated that the Thinking Frames Approach improves children's confidence and can significantly raise their level of achievement in science. Thinking Frames motivate and engage children by giving them ownership of their own problem solving and enquiry explanations.

Thinking Frames are exactly that, they are not writing frameworks, but scaffolding that can help to break down children's thinking into small steps, acknowledging that it is important to stop, reflect and organise thoughts before committing them orally or to paper. They might support writing, but they are primarily used to help children to organise their thoughts. 'Thinking Frames' can serve a range of purposes depending on the needs of the learner, for example, they can support children in:

- thinking through a plan
- making sense of evidence
- using ideas to solve problems
- constructing argument
- looking at something from a different perspective

This can be done by using 'Thinking Frames' that:

- focus on vocabulary
- sequence ideas
- join up ideas, sometimes from different sources

'Thinking Frames' can be used by individuals, however science is a collaborative endeavour, and using a 'Thinking Frame' with others means that children's ideas are then public and so they can be added to, challenged, changed as well as endorsed. 'Thinking Frames' can take many different forms, many ideas of which are presented well in Active Assessment (Naylor et al, 2004), such as:

- odd one out activity
- true or false quizzes
- PMI (Positive, Minus, Interesting)
- teacher and peer effective questioning
- photographs
- graphic organisers
- card sorts, a set of cards etc.

A problem solving framework long established by the Comino Foundation is **GRASP – Getting Results And Solving Problems**. This framework encourages people to want to succeed and enables them to develop their self-esteem, enterprise and initiative, their ability to lead and to work with others, to be creative in their thinking and decision making, and to accept personal responsibility for their decisions and actions. Taken simply it looks to help the learner establish clearly what they really want to achieve, to explore the options available to them to succeed and to take ownership over the course of action and its outcomes.

GRASP has a clear association with scientific enquiry process and therefore has implications for work in primary classrooms. It has been actively integrated into the Smart Science Resource, making it accessible to youngsters for use in all areas of the curriculum.

What do I (or we) really want to achieve?	Purpose
How will we know when we have achieved it?	Criteria
What possible ways can we use to get the result?	Alternatives
Which one best satisfies the criteria?	Selection
How will we know if we are keeping the process on track and what action to take if we are not?	Monitor & Control
Are we reviewing continually our purpose, the success criteria, our progress and finally the result?	Review

GRASP ENCOURAGES PEOPLE TO WANT TO SUCCEED

Reflect on

- What do you think are good reasons for using 'Thinking Frames'?
- Have you a generic set of 'Thinking Frames' to suit different learners across the curriculum? If not, what actions could you take to develop one?
- How would/should 'Thinking Frames' develop across the primary years? Think about progression.
- How will you know when children no longer need an imposed framework?

References, useful reading and links

Naylor S, Keogh B & Goldsworthy A. (2004) *Active Assessment for Science: Thinking, Learning and Assessment in Science*, David Fulton Publishers.

GRASP –

www.cominofoundation.org.uk/D1_GRASP.html

www.azteachscience.co.uk/resources/cpd/the-thinking-frames-approach/view-online.aspx

<http://media.education.gov.uk/assets/files/pdf/c/camshill.pdf>

www.thinkingframe.com/

www.azteachscience.co.uk/science-teaching/continuing-professional-development/discussions-in-primary-science/view-online.aspx



G

GROW – Goals, Reality, Options and Will

The GROW model is a technique for problem solving or goal setting, championed in the UK by Graham Alexander, Alan Fine and Sir John Whitmore and is often used for the purpose of coaching. The value of GROW is that it provides an effective, structured methodology which both helps set goals effectively and is a problem solving process.

There are a number of different versions of the GROW model. This version presents one view of the stages but there are others.

G	Goal	This is the end point, where you want to be. The goal has to be defined in such a way that it is very clear to you when you have achieved it.
R	Reality	This is how far you are away from your goal. If you were to look at all the steps they need to take in order to achieve the goal, the Reality would be the number of those steps they have completed so far.
O	Options	Sometimes also including an exploration of the obstacles, this stage asks you to identify ways of dealing with them and making progress. These are the Options.
W	Will or Way Forward	The Options then need to be converted into action steps which will take you to your goal. These are your 'Wills' or ways forward.

The GROW model has been adapted and used in a number of primary science projects, for example, the Centre for Science Education's Smarter Schools Project (funded by AstraZeneca Science Teaching Trust). In this project groups of teachers engaged in moving science in their school forward through professional peer coaching.

I have valued the time to reflect on practice and use the GROW approach to think about coming to my own solutions.Without the time to reflect on what had actually happened in the classroom I'm not sure I would have so definitely defined or recognized what went well and therefore done anything about it.

Teacher AZSTT Final Report Smarter Schools Project

The potential of GROW as a tool for reflection was also extended to work with children in the Smart Kids Project. In this work we explored how children, mainly from Key Stage 1 and 2 could be supported to undertake peer-pupil coaching activities as a means of reflecting on their science learning and their development of personal skills and capabilities.

The use of GROW, in fact, was met with mixed reviews by the children, some, especially girls, liking the structure, others finding it too restricting – and many children wanting very much to offer help and support by giving information and answers, as opposed to helping peers reach their own understandings and conclusions. Reflective prompts were produced in this project, as shown here, which helped the children self-coach and review with peers. In this way, the GROW approach was tailored and the insights gained were invaluable, especially with respect to GROW as a stimulus or framework for self and peer assessment.



Reflect on

- What would happen if you combined the GROW model with approaches to your science planning?
- What impact could the GROW model have if applied to problem solving in relation to your own professional development, school issues or indeed your discussions with children?
- Why could the GROW model be significant in your work in school or in the classroom?

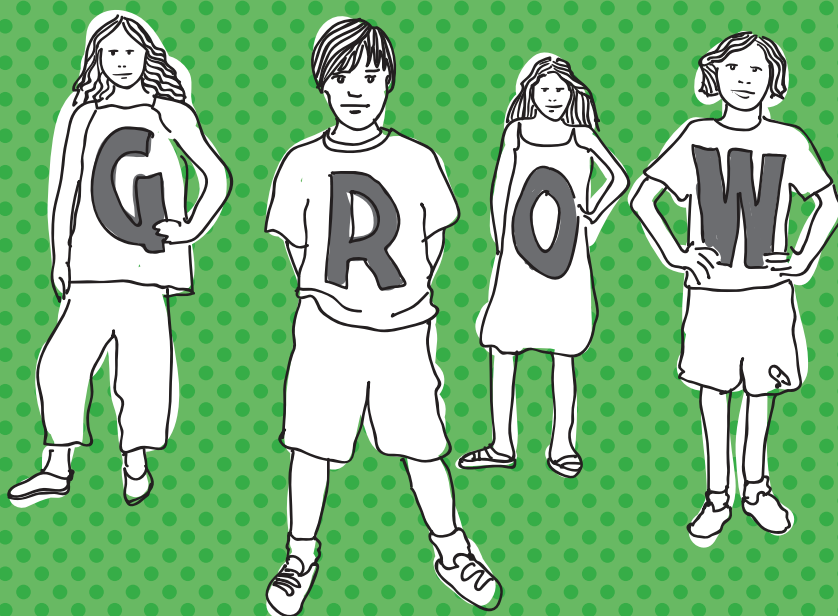
References, useful reading and links

AZSTT Final Report Smarter Schools Project, accessible by emailing l.m.bianchi@shu.ac.uk

AZSTT Final Report Smart Kids, accessible by emailing l.m.bianchi@shu.ac.uk

Smarter Schools Online CPD Unit

<http://www.azteachscience.co.uk/resources/continuing-professional-development/smarter-schools.aspx>



H

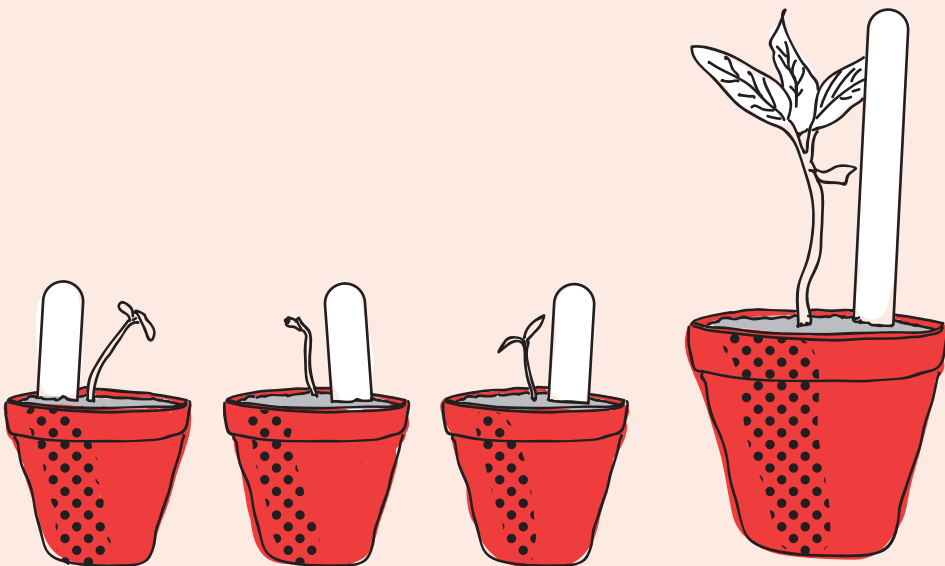
High Achievers

The National Association for Gifted Children (NAGC) acknowledges that there is no universally agreed definition to what is a gifted child and the ideas of what constitutes giftedness are fluid concepts. The term gifted may narrow our view of the very able in science; when considering the term 'gifted' many people, think of Einstein and hold limiting views of gifted children for example, that they will do fine on their own, they can learn by themselves, and teachers may lack confidence because they see gifted pupils as more knowledgeable than themselves.

Change the term to 'high achievers' and our perceptions may change, immediately the term becomes more inclusive allowing teachers to consider expanding opportunities for children considered to be high achievers. The aims for high achievers are the same for all children and that is to challenge and extend their scientific knowledge, skills and thinking. The difference is that their starting point is different from other children in the class, and they have the potential to exceed the level of most of the children in the class.

What we must remember is that children can join this group at any point in their primary career, some will clearly be more able in the early years, whilst others, might not come to the attention of the school as a high achiever until later.

What is clearly important is how the school responds to managing provision for this group of learners. Most experts in the field would agree that schools should offer high achievers access to enrichment/extension activities, thinking skills activities, differentiated activities and approaches that encourage family involvement. You could argue, of course, that in fact all children should be offered these opportunities in science, and that sentiment couldn't really be disputed that much, could it?



Nevertheless we do need to explore our offerings for these children, which might include:

- accelerated learning in areas of interest, offering children opportunities to advance their learning beyond that offered to the rest of the class. Accelerated learning should not narrow high achievers experience (for example, by focusing on fast tracking knowledge of plants by introducing, photosynthesis) but broaden it to include, debate, problem solving, contemporary applications of science e.g. food miles, GM crops, use of pesticides.
- specialist activities to broaden further children's access to areas of science which challenge children's perception of science and scientists and also help to sow the seeds for choice in science linked careers e.g. giving children access to scientists through the Science Ambassador scheme.
- master classes which give children access to 'experts' and provide opportunities for children to deepen their understanding and participate in activities that the teacher either would not have the personal knowledge to provide or the physical facilities.
- summer schools to give children a sense of community, enabling them to work with children of a similar ability and interest in a leisure based context.

Reflect on

- What is a high achiever in your school?
- Why might the use of the term 'high achievers' rather than gifted, be significant in your school?
- What evidence can you list for how high achievers are currently being supported in your school?
- If you were to design a new approach to supporting high achievers what would it include?
- What do you consider to be the priorities in relation to supporting high achievers in primary science?

References, useful reading and links

<http://www.nagc.org/index.aspx?id=574>

<http://www.brookes.ac.uk/schools/education/rescon/cpdgifted/cpdresources.html>

<http://www.nace.co.uk>

<http://www.nagty.ac.uk/>

<http://www.nagcbrtain.org.uk/>

**SPECIALIST ACTIVITIES HELP TO
SOW THE SEEDS FOR CHOICE
IN SCIENCE LINKED CAREERS**

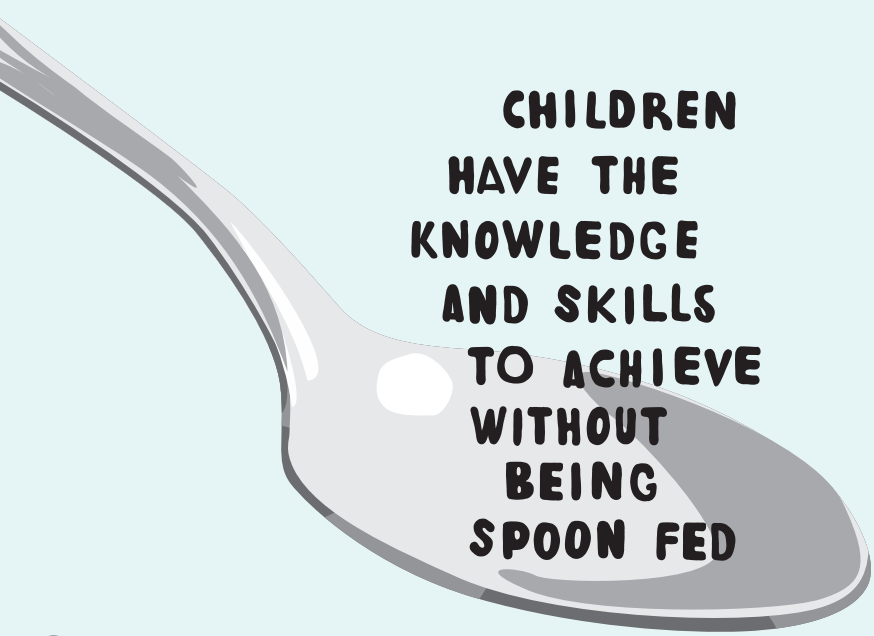
Walk into most early years settings and you will find children busy choosing where to work, deciding who to work with and indeed walking away when they have had enough. Routines are set in place where they can get out the things that they want to use, and they know that they need to put things away. Often they spend considerable time exploring something that interests them, asking questions, seeking out new information and help when they want it. Fast forward through the primary years and for many children independence changes, the balance of personal choice and power shifts from the child to the teacher. In primary science this often manifests itself as science which is primarily organised by the teacher, adhering to a given curriculum or scheme, where experiences are heavily scripted by the teacher.

An environment where independent learners thrive is characterised by choice and personal decision making, and much less by a teacher-managed, staged approach to learning. Of course, this type of approach doesn't come without its risks for a teacher, it doesn't take long to see that one might be judged as having lessons that lack pace towards achieving identified learning outcomes.

So, the question is again, what do we value? What do we want in our learners? How do we achieve our desires within the boundaries of our school and educational cultural rules?

Firstly, let's establish what independent learning in science might look like. It could be characterised by any or all of the following. As you read, consider what other criteria you would add.

- Children engaged in activities of their own choice.
- Children engaged in activities which allow them to manage how they work.
- Children reflecting on what and how they have learned.
- Children reflecting on their own success.
- Children working at their own pace.
- Children choosing who to work with where they want to work.
- Children initiating their own learning.



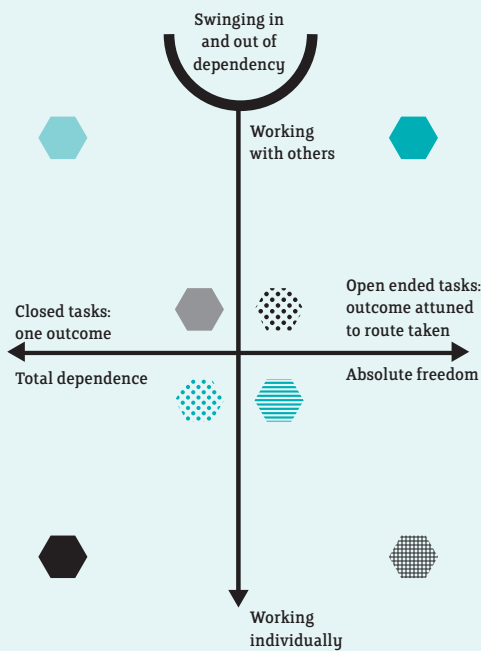
**CHILDREN
HAVE THE
KNOWLEDGE
AND SKILLS
TO ACHIEVE
WITHOUT
BEING
SPOON FED**

Graham, K. (2003) acknowledges that in the short term our worst fears might be realised, but counsels us to work through any potential pain barrier so that children can become independent learners in science.

Of course, if children are not being spoon-fed the apparent standard of work may drop initially, but with a long-term view standards will increase because children will have the knowledge and skills to achieve away from the spoon. It is vital that we take this long-term view.

Have a go at this activity.

Look at the Independence Pendulum and match one of the activity descriptions to each of the coloured hexagons.



Independence pendulum

Reflect on

- Why is independent learning important to you? To your learners?
- What strategies will help children to develop as independent learners?
- Which of these strategies do you use in your classroom?
- What are the potential tensions between covering curriculum content and encouraging children's independent learning development?

References, useful reading and links

Graham, Karen (2003) *How Can Children's Independence be Promoted and Measured in the Primary Classroom?* PhD thesis, Coventry University in collaboration with University College Worcester. <http://eprints.worc.ac.uk/376/>
http://www.highlandschools-virtualib.org.uk/lt/whole_learner/independent.htm accessed 25/4/11

A Collaborative. Working in a team doing a specifically defined job. Route and role defined. Little creative influence. e.g. comparing measurements of people's head circumferences using a tape measure	B Outcome defined. Route/role suggested but some influence over it if desired. Working in pairs. e.g. investigating the best conductor. Materials of their own choice, brainstormed class ideas for method
C Co-operative. Working in groups. Outcome defined. Route/role suggested but some influence over it if desired. e.g. using data loggers to track temperature of a range of cooling liquids	D Working in pairs. Objectives defined. Route/role negotiated. Outcome semi-flexible. e.g. categorising a range of waste materials. Own choice of what the categories will be.
E Co-operative task. Working in groups. Objectives defined. Route/role negotiated. Outcome semi-flexible. e.g. making an alarm clock for deaf people, choosing from a range of chosen equipment	F Individual project. Working alone with some guidance/mentoring. Route and role defined. Little creative influence. e.g. growing a broad bean, following instructions and using equipment provided
G Collaborative. Working in a team. Route/role flexible. Objectives undefined. Outcome flexible. e.g. exploring the snow and ice, thinking about investigations to do with it or a question to answer	H Individual project. Working alone with some guidance/mentoring. Route/role flexible. Objectives undefined. Outcome flexible. e.g. doing a project on rockets or a topic of their choice

Activity description

“The best way to predict the future is to build it.” Douglas Adams

Politicians and governments will come and go, and therefore so will many different approaches in education but the constant is the teacher and the child. All schools are different and one size really does not fit all, and the only way to move science education forward is to help to build the future through continuing professional development which includes action research.

By engaging in action research the teacher seeks to answer a question or solve a problem in order to improve primary science education. This, by default engages the teacher in a reflective practice which enables the teacher to shift parameters and personal boundaries of their professional practice and thereby change the science experience of children. By communicating the outcomes of action research and sharing it with other teachers we can help to change practice and shift the parameters in primary science education. Where we have a clear understanding of why we are using certain approaches, that is, we have a personal pedagogical underpinning, then we are more able to justify approaches when challenged. Having a clear rationale approaches for the methods we use invariably means that we have explored our options and can explain why something is or is not appropriate.

At the simplest level action research involves a spiral or cycle of planning, action, monitoring and reflection (indeed not far dissimilar to a professional use of the GRASP Framework outlined on page 16).

Figure 2: Basic Action Research Cycle



Engaging staff in this level of critical analysis and reflection is crucial to all aspects of education, not least primary science. This means that we need to create and manage opportunities for staff to engage in this kind of professional development.

We need to constantly challenge our current approaches to teaching in primary science, through engaging in our own action research, in dialogue with colleagues and other professionals external to our setting.

If we reflect on past action research projects we find that they have provided justification for approaches that are now considered as the norm in science education, for example:

- Constructivism
- Concept cartoons
- SMART Science
- Argumentation in Primary Science
- Primary Horizons: Starting out in science

'Primary Horizons' is based on a research study conceived and commissioned by the Wellcome Trust in 2004 and carried out by Queen's University Belfast and St Mary's University College Belfast. Whilst not action research in the classroom, this research project is thought to be the largest study of its kind, which explored teachers' views and experiences of primary science education across the UK and identified ways in which it could be improved. By engaging teachers in this research project the study has subsequently been used to inform change in primary science.



AT THE SIMPLEST LEVEL ACTION
RESEARCH INVOLVES A SPIRAL OR
CYCLE OF PLANNING, ACTION,
MONITORING AND REFLECTION

By ensuring that teaching and learning is properly informed by research whether our own or carried out by other groups, we can avoid pedagogical fads, which may only result in quick fixes, not long lasting change in practice.

What we do need to recognise is that action research can be carried out by anyone, an individual with their own class, a group of teachers in school; it might be a collaboration with the community, or a research project instigated by a large institution. So all teachers can have access to being involved with action research and contributing to change in primary science.

Reflect on

- What action research do you know about?
- How could you share the outcomes of action research with your colleagues?
- What would you like to action research?
- How would an action research contribute to teaching and learning in science in your own school?
- How could you set up an action research group in your school or cluster group?

References, useful reading and links

Harlen, W. (2011) *ASE Guide to Primary Science*, Hatfield ASE

Primary Horizons: <http://www.wellcome.ac.uk/About-us/Publications/Reports/Education/WTX026627.htm>

<http://www.azteachscience.co.uk>

K

Knowledge

At the time of writing this it is the 200th anniversary of the birth of Charles Dickens; amongst his many characters is Mr Gradgrind from the novel *Hard Times*. Gradgrind believed in facts, and all that was measurable.

"Now, what I want is, facts. . . Facts alone are wanted in life," states Mr Gradgrind, someone whose educational philosophy could not be more far removed from the values that we hold today.

In science today there are facts that we want children to know, such as light travels faster than sound, and the Earth moves round the Sun.

Or do we?

Is it the fact or the underpinning knowledge that we seek; the fact can be repeated without understanding and we suggest this is of little use to anyone. The knowledge that allows us to understand the fact, and then use this information is what is important – but what kind of knowledge is this?



We query:

- Is there more than one kind of knowledge in science?
- How do they relate to each other and is one useful without the other?
- How many of these have you come across and what place should they have in the primary science curriculum?
- If they should have a place, how, what, where and when should they be included and developed?

Here are some types of knowledge that we undoubtedly already address – but are there any that you find more difficult to tackle in primary science?

1. Knowledge about the nature of science.
2. Content knowledge – knowledge about the material and natural world
3. Conceptual knowledge which refers to a person's representation of major concepts in science
4. Procedural knowledge about how to think and work scientifically.
5. Epistemic knowledge the nature of knowledge that is produced by scientific reasoning
6. Knowledge about science in society
7. Knowledge of self – knowing one's strengths, one's personal capabilities and how to use and apply them when thinking and working scientifically
8. Everyday knowledge that is based on experience and might even conflict with what is scientifically correct at the time.

Reflect on

(Just a few questions to reflect on; it makes Gradgrind's simplistic approach almost appealing!)

- How well do you understand the different kinds of knowledge in science?
- Which one are you most comfortable with, why?
- Which do you understand the least?
- Which ones are represented in your primary curriculum, how well?
- Which ones should be represented in the primary science curriculum? Why?

What does it mean to empower children as learners and develop their leadership qualities? Be that in terms of leading their personal learning, or leading a group in their learning in an activity?

Taking the lead in the classroom can be interpreted in different ways, from considering whose agenda do we work with in the classroom – be it the teachers' (driven by a curriculum demand) or the children's (driven by their interests and motivations). To develop children as leaders we must challenge ourselves and consider the extent to which we encourage children to be masters of their own learning in science.

Of course this is a great leap to make and small steps are often the most successful. In primary science we can extend opportunities for children to drive or lead their own learning. We should respect children's experience, allow their voices to be heard and make sure that they are actively engaged in decisions about how, when and where they learn in science.

Bianchi, L. & Feasey, R. (2011 p.41) suggests that we need to create situations where 'Children can gradually move from regulation by others to self-regulation.' This is the basis of much of the work undertaken in valuing and developing children's personal capabilities – encouraging them to appreciate 'how' their behaviour influences 'what' they learn. But this needs to happen over time using scaffolded approaches to support the change in role.

A simple, yet very effective technique is the use of 'role badges' which provide young children with a clear purpose and area of responsibility. Often used in science investigations and especially good when children are learning science outdoors, roles range from:

- Chief Tester
- Chief Resource Manager
- Chief Measurer
- Chief Recorder
- Chief Time Keeper

Using these role badges supports children in moving towards working independently as a group, each managing their role, whilst working collaboratively to solve a problem or answer a problem. In some classes these roles are different, mirroring roles and responsibilities in industry, for example, health & safety officer (clean up any spills, clean equipment), administration officer (do all recording), communications officer (feedback from group), personnel officer (ensure that everyone is doing their job). Whichever approach is used what we are trying to encourage is leadership in children, by introducing them to individual responsibility.

Waller, N. (2006) recounts how a class of children carrying out a science activity led in their individual roles, and Jake proudly explained, "I'm also in charge of health and safety in the group, my job is a bit like an engineer."

Leadership is an increasingly topical issue in schools, as OFSTED explore ways that it is encouraged throughout the school. This includes developing leadership capabilities in our youngsters. We must be brave enough to allow children to explore new parameters in their learning by increasingly taking charge. Outdoor learning offers perfect opportunities to see how children cope leading their own learning – management of resources, time and space are all.

Reflect on

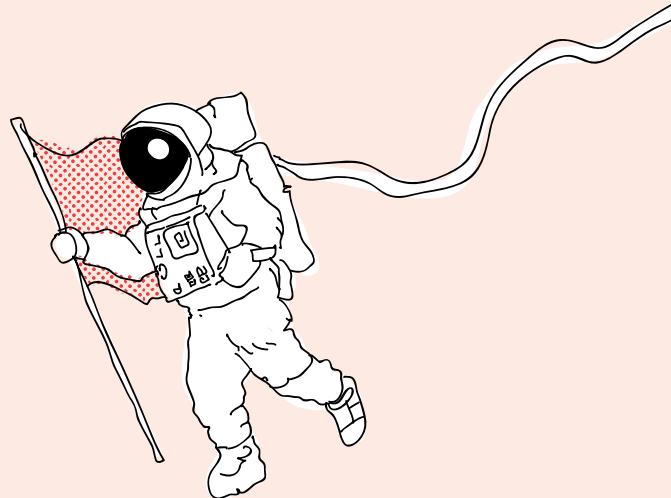
- Where does the balance sit in your class in terms of who leads science?
- What are the issues in shifting that balance further in favour of the children? How could barriers be overcome?
- How can you scaffold the children into leadership roles in science?
- How does this translate into children leading their learning?
- What whole school strategies could be introduced to support children leading in science?

References, useful reading and links

Bianchi, L. and Feasey, R. (2011) *Beyond the Classroom Boundaries: Fro 7 – 11 year olds*. Berkshire: Open University Press.

Waller, N. in Primary Science Review Sept/Oct 2006 17
Real science for primary age children
[www.personalcapabilities.co.uk/smartscience/](http://www.personalcapabilities.co.uk/smartsience/)

**THIS IS A GREAT LEAP BUT
SMALL STEPS ARE OFTEN
THE MOST SUCCESSFUL**



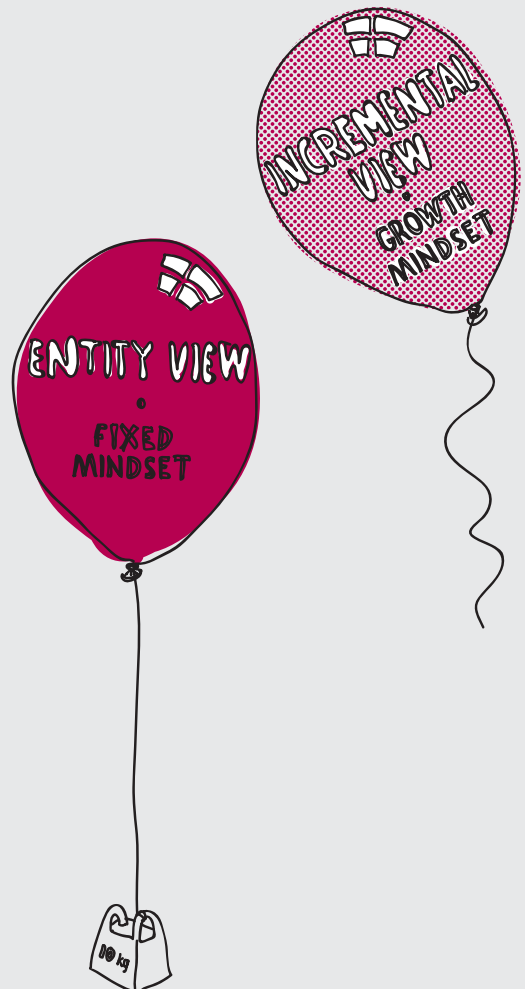
M

Motivation in Learning

For this part we would be silly not to review the work of Carole Dweck, whose research has provided much food for thought around motivation in learning. Carol is an American researcher whose research has illustrated how motivation for learning is affected by children's theories about themselves.

Her studies have investigated how people develop beliefs about themselves (their self-theories) and how these lead to a shaping of their thoughts, feelings and day-to-day behaviours. The theories explain why some students are motivated to work harder, and why others fall into patterns of helplessness and are self-defeating.

1. **The Entity View** – which would indicate that intelligence is fixed. That you are born with an IQ that determines the capacity for learning. Such students have a strong desire to prove themselves to others and wish to be seen by others to be smart.
2. **The Incremental View** – which treats intelligence as malleable, fluid and changeable. These students gain satisfaction from the process of learning and seek opportunities to get better. They do not focus on what the outcome will seem to say about them, but they focus mostly on the taking part.



Dweck suggests that entity theorists are more likely to feel helpless and to blame circumstances they feel are beyond their control. Because of this these students are more likely to lack motivation and to give up – feeling that they are not in a position to influence change. They either avoid challenges or indeed seek them out to provide a seemingly justifiable reason for failure.

Incremental theorists however display alternative behaviours, and enjoy challenges as they see that by investing effort they are engaging in more fruitful learning, even though difficult, they flourish in the pursuit of an outcome. If they do encounter failure, they do not give up but seek alternative ways to get around the problem, they value the way they seek out new strategies seeing this to be in their favour. As such their motivation for learning increases and self image is enhanced.

This work has obvious implications for learning in all subject areas, and indeed for primary science. It should influence the way we praise and reward our children, whether our language should shift to reward effort-full learning – 'Well done, that was a real challenge and you made a great effort to find different ways to go about it!'. By moving towards this type of praise children are more likely to appreciate that they are in charge of their own intelligence and by investing effort they can improve. This is contrast to feedback which may reinforce an entity view – where a child might be praised for being clever, getting all the answers correct, getting things right the first time.

Dweck's work is ongoing and contemporary and prompts personal and professional reflection. What type of a beliefs do you hold of yourself? You might also be interested to find out what children think about their own intelligence, whether it is fixed, or they can develop it and how this affects ourselves as learners.

Reflect on

- What is your view of your intelligence, is it fixed or can you continue to develop it?
- How do you think your view impacts on how you learn?
- What effect do you think it has on high achievers?
- Do you think people with a fixed view of intelligence are more likely to be risk takers?
- What implications does this idea of fixed or malleable intelligence have for teaching and learning in science?

References, useful reading and links

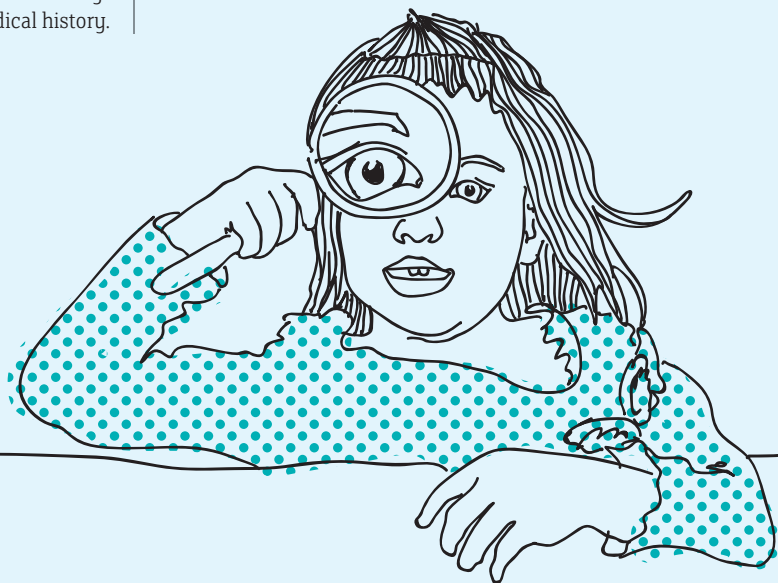
Dweck, C. S. (1999). *Self-Theories: Their role in motivation, personality, and development*. Philadelphia, PA: The Psychology Press.

Dweck, C.S. (2011) *Mindset: How you can fulfil your potential*, Ballentine Books.

Children are naturally curious: how often have we heard that phrase? Curiosity in children is seen when they display inquisitive behaviour which might be observing something, touching, tasting, smelling or listening to something. In primary science we aim to capitalise on children's natural curiosity and encourage them to use it to explore new experiences and ideas. Fuelling their curiosity leads to broadening experiences.

Of course it is only natural that children want to share the outcomes of their curiosity with their parents, siblings, friends and teachers by showing or talking about their experience. The excitement and the intimacy of sharing with another are important human emotions, one suspects that scientists both past and present have delighted in sharing with others their ideas or what they have found. Of course this success means that both scientists and children are likely to want to repeat what they have done and learn more from it. It is this natural curiosity that is the foundation of science, at all levels of experience and expertise. Thankfully Fleming was curious when he noticed that one of the plates he had left in a pile had mould on it. The mould was in the shape of a ring yet the area around the ring seemed to be free of the bacteria staphylococcus he was studying. Curious Fleming observed more closely and concluded that it must be something to do with the ring of mould. Of course we now know that his curiosity and subsequent discovery of penicillin has played a major part in medical history.

**CREATE A CLASSROOM
ENVIRONMENT THAT
PROMOTES AND FEEDS
THE CURIOUS MIND**



What can we as teachers learn from this?

- To value curiosity and its associated questioning.
- To encourage curiosity through creating a school and classroom environment that promotes and feeds the curious mind.
- To provide opportunities and different contexts in which children are encouraged to be curious, include books, the internet, artefacts, questions, and access to experts.
- Not to limit curiosity through careless responses such as 'yes I know', 'we haven't got time', 'get on with your work'.
- To allow children to follow lines of curiosity not only in school but also in their own time whether that is during school breaks or at home.
- To build bridges between school and home, so that adults at home have an understanding and appreciation of the nature and importance of children's innate curiosity to their development in science.
- Try not to take short cuts and telling children what to do or the answer! Being curious is about finding out for oneself, just because we are older and more experienced does not give us the right to curtail someone else's opportunity to find out for themselves.
- Introduce children to scientists and celebrate their curiosity to help children understand how some of the greatest discoveries and inventions are due to someone's curiosity

It is interesting to note the work of the Imaginative Education Research Group. Founded in 2001 in the Faculty of Education at Simon Fraser University, Canada, this group want to help bring about a change in the way schooling is conceived, organized and practiced worldwide. They explore ways of teaching that are based on engaging learners' imaginations. Imagination being the ability to think of what might be possible, in a manner that is not tightly constrained by the actual or taken-for-granted. A current research project of theirs, the Learning in Depth Programme, offers a novel way to stimulate children's imaginations. In this children are randomly assigned a topic in their first week of schooling, e.g. pets, trees, dust, rockets. They research this over the duration of their school life. Where some challenge the researchers by suggesting the children would be bored by the same topic, especially when they do not choose it themselves, they suggest that what actually happens is that children begin to realise the scope of knowledge out there and that in fact the more you know about something the less you find it boring.

They suggest that such topics engage curiosity, especially after the first 3 or 4 years, such that by the age of 12 the children know more about it than most people. It will interesting to note the outcomes of such research and to explore how children's natural curiosities map the journeys within this programme.

Finally, we will close this short section with a quote from Nickerson in Sternberg 1999:410 who likens curiosity to 'intellectual playfulness – finding pleasure in playing with ideas.' He puts forward a suggestion that only prompts us not to wain in our endeavours to allow our youngsters to pursue their own questions about the world and themselves.

'It could be, too, that all children are curious and that whether they maintain their curiosity into adulthood depends to a large degree on the extent to which it is encouraged or inhibited in early life.'

Reflect on

- How would you create a unique environment to nurture children's curiosity in science?
- What do you think are the most important approaches to creating a creative environment which supports children's curiosity?
- How might curiosity and independence be linked?

References, useful reading and links

- Feasey, R. (2005) *Creative Science: Achieving the WOW Factor with 5-11 Year Olds*, London: David Futlons Publishers Ltd.
- Sternberg, J. (Ed.) (1999) *Handbook of Creativity*. Cambridge: Cambridge University Press.
- Learning in Depth Programme: www.ierg.net

There is a long history of what is taught there, by whom and how, as well as embedded perceptions about the types of buildings and spaces where these practices traditionally occur. However, there is a need to challenge existing assumptions... this requires taking a different approach to imagine a whole range of different possibilities.

Futurelab (2008: 12)

Put quite simply, the school grounds are both accessible and free providing the opportunity to make the most of what we have! Our goals should be to:

- rethink where science learning takes place and to move most science learning 'Beyond the Classroom Boundaries;
- redevelop the outdoor spaces around our schools so that they provide a wide range of opportunities for teaching and learning in science and associated Personal Capabilities.

Robert Brown MSP, the then Deputy Minister for Education and Young People offered a thought provoking question when he commented:

'We must challenge people to think: Why learn indoors?'

www.ering.net/educ_visits/learning.shtml [accessed 25.06.10]

Underpinning this is the resolve to develop children's Personal Capabilities (Bianchi, L. 2006) so that eventually children are able to choose why and when to take their learning 'Beyond the Classroom Boundaries', on a regular basis.

The question is how will you do this? It is perhaps easier than we think if the challenge is broken down into small stages, for example:

1. Identify how the grounds are currently used for science.
2. Identify the potential of the school grounds for science, by asking what do we have outdoors that links to science?
3. Involve children and the local community in developing the school grounds to support science.
4. Develop an action plan to redesign and use all appropriate elements of the school grounds.
5. Explore with staff and children, how creative and innovate practice and resources to support learning outdoors, can be embedded across all aspects of the science curriculum.
6. Think about how you will celebrate your success.

Practical ideas for taking primary science outdoors (taken from Bianchi & Feasey (2011) Beyond the Boundaries)

Clay tile invertebrate decision tree

Tiles of about 10cm². Each tile has the outline of an invertebrate found in the school grounds, such as an ant, beetle, woodlouse, bee, either in relief of indented into the clay. Children are challenged to model their invertebrate using clay ensuring it is scientifically correct, e.g. in proportion with correct body parts. Once hardened the clay tiles are sealed using an outdoor varnish, and mounted as part of an outdoor decision tree. Each tile is fixed low down on an outdoor wall, using 'No Nails Glue' so that the tree is accessible to all children. Connecting lines are painted on with an outdoor emulsion.

Outdoor Skeleton

Children are organised into small groups and given access to small P.E. equipment such as skipping ropes, bean bags, rounders bats, team bands and quoits. They are asked to model a human skeleton using the equipment and create labels on white boards. Using photographs to capture the evidence, these can then be placed in big books or on the school website etc. Of course skeletons aren't the only model appropriate here!

Snowman's Coat

This example encourages you to use what's out there today! Snow, puddles, wind, rain, sunshine. On a snowy day you may encourage the children to go out and build a snowman. Investigations exploring how to stop the snowman melting, using photographs to track over time are motivating and engaging to the children. In the same light watching puddles change, tracking shadows, flying kites are all simple, yet science-rich explorations.



Issues that may crop up but that can be overcome.

Issue	Suggested Strategies
Health and safety	Behaviour guidelines Children work in threes or more, learning to look after each other. If there is an accident e.g. child falls over, one stays with the child, the third leaves if necessary and tells adult in school. Resources that can help: timers/watches, role badges, cones to mark off physical boundaries, coloured flags (teacher waves particular flag to call particular groups back inside).
Time	Time is only an issue if this is seen as an 'add on' to science lessons rather than a regular and integral part of science.
Ratio of staff to children	The use of the school grounds should be seen as the classroom without a roof – the fencing provides a boundary. Class rules for working in the outdoors should help the issue of needing additional staff, as children become able to 'police' themselves, staying within given area and behaving responsibly.
Weather	Foundation have wet weather clothing. Children put coats and wellies on to go outside. Cold weather should not be a deterrent. Summer weather – hat and sunscreen if out for extended periods.
Differentiation	Should be based on approaches used in the classroom and appropriate to the activity, e.g. levelled groups for fair test investigations, mixed ability when they are exploring or carrying out surveys, sometimes groups will have reader with non-reader
Which areas of science	Only areas that are appropriate – for example, it isn't really appropriate to make circuits in electricity outside.

Reflect on

- What could the term 'open' classroom mean?
- Why do we need to challenge perceptions of what it means to learn as a primary scientist?
- How are personal capabilities central to working beyond the classroom boundaries?
- How can working beyond the classroom boundaries empower children?
- How can outdoor learning contribute to children's well-being?

References, useful reading and links

Bianchi, L. & Feasey, R. (2011) *Beyond the Classroom Boundaries 4 – 7 years*: Open University Press

Futurelab (2008) *Reimagining outdoor learning spaces Primary capital, co-design and educational transformation*. Bristol: Futurelab.

http://www.eriding.net/educ_visits/learning.shtml
[accessed 7.3.12]

The Smart Science materials (2006) developed by the Centre for Science Education have been mentioned already in this booklet. They explore how Personal Capabilities can be embedded in the science curriculum which was first researched by one of the authors of this booklet. Her assertion is clear, children's learning in primary science, and indeed beyond it, benefits when experiences are tailored to support the learning process (the 'how are we learning') as well as the 'what' of learning – the knowledge.

By engaging in generic games and tasks, children's self-awareness of their personal strengths and capabilities increases, enabling them to be able to identify those areas of skill that they feel are their strengths, e.g. I think I am good at sharing my ideas and opinions; I like to take time to be imaginative; I find it difficult to stick at a task. They start to develop as 'personally literate' individuals. Capitalise on these generic experiences by assisting them to apply their personal skills and capabilities in science tasks, then assist the transfer of skills, and provide meaningful contexts for the use of their personal skills. Essential is the need to scaffold the children's transfer of skills, with the use of talk (e.g. think-pair-share), thinking frames (e.g. graphic organisers), visual prompts (e.g. role badges) and active review strategies (e.g. self and peer assessment tactics – thumbs up/sideways/down; traffic lights).

Five Personal Capabilities addressed within Smart Science are:

1. Self-management – taking charge of your own learning
2. Teamwork – working well in groups and teams
3. Creativity – coming up with and sharing new or unusual ideas
4. Problem-solving – analysing problems and developing strategies and solutions
5. Communication – speaking, listening and sharing feelings with meaning

These capabilities have often been thought of as being endpoints in themselves, for example, once children are more aware and able to communicate, or manage themselves they have achieved the required outcomes. Yet these are the first steps and foundations of development, from which children are increasingly 'personally literate'.

Personal Literacy:

- having the knowledge and understanding of one's personal skills and capabilities
- being able to speak with confidence about their own personal development
- articulating which particular aspects of a skill are relevant to them and why.
- developing a strong sense of what they can do to help improve their abilities
- acknowledging where they need or could find support
- having the self-confidence to demonstrate their skills to others, receiving and giving feedback where appropriate.

Reflect on

- What difference do you think embedding Personal Capabilities in the science curriculum might make to children's experience in science?
- In your own context which of the Personal Capabilities are most relevant?
- How would you encourage children to value Personal Capabilities?
- What behaviours would you expect to see when judging whether children are developing Personal Capabilities?

References, useful reading and links

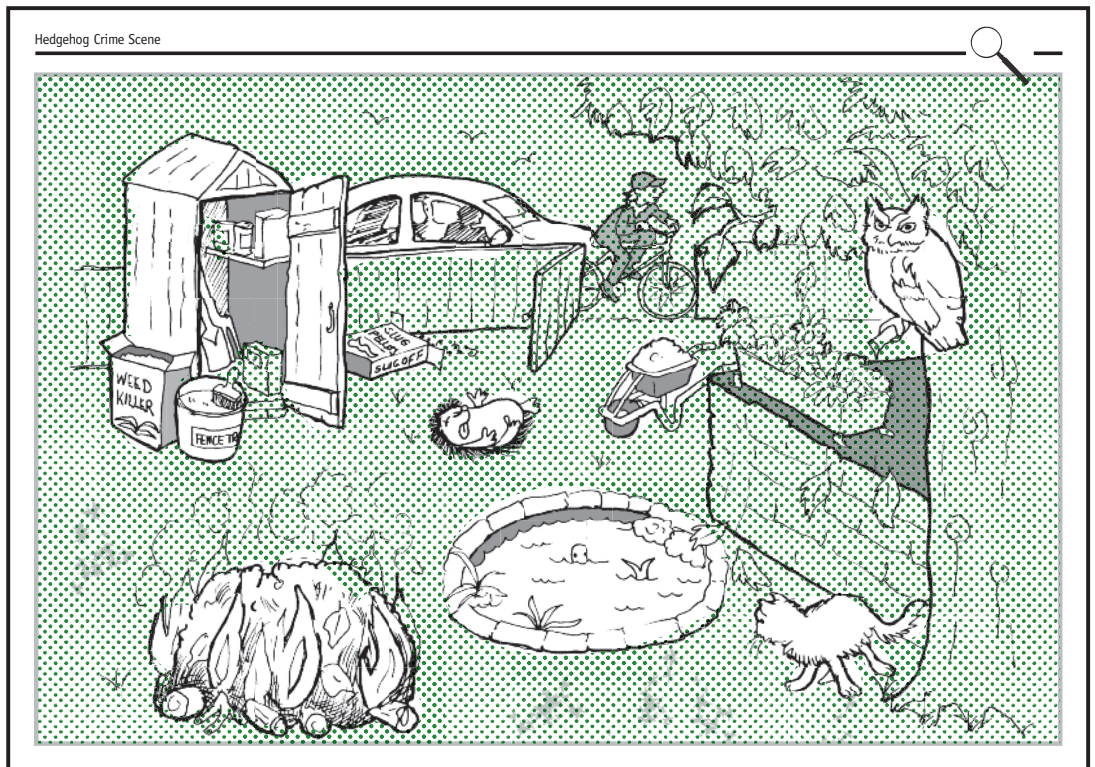
Bianchi & Barnett (2006) *Smart Science*, Centre for Science Education, Sheffield Hallam University.

URL: www.smart-science.co.uk

www.personalcapabilities.co.uk

An example of a Smart Science activity, Hedgehog Crime Scene, focusing on:
 Creativity & Problem Solving: to consider Why? How? and What if?
 Investigative Skills: to make comparisons between pieces of evidence

Generic Task	Embedded Task
<p>If... then...</p> <p>Explain that part of thinking creatively and solving problems involves foreseeing what could happen in different situations. This task poses lots of different 'if...then...' scenarios which encourage the children to think freely and give a quick response.</p> <p>Explore through discussion:</p> <ul style="list-style-type: none"> If trees could talk, then... If promises had to be kept... If we were one inch tall, then... If no one needed to eat, then... If people didn't have skin, then... If all people were boys, then... If there were no diseases, then... If rocks were flexible, then... If gravity didn't exist, then... 	<p>Ask groups of children to look at the picture evidence and to consider all the possible reasons why Norman the hedgehog might be unconscious. As them to suggest, 'If...then...' or 'What if...' possibilities.</p> <p>Then using samples of extra evidence challenge them to agree on one or two most likely scenarios. What other questions might help you find out if your suggestion is true?</p> <p>Review by emphasising the idea that in a complex situation like this, open questions, such as 'Why?' 'How?' and 'What if?' encourage us to consider different possibilities. They help us to think more freely and creatively about options and when new evidence is found we review this in an open minded way and if necessary refine our initial thoughts.</p>



Q

'When Socrates defined teaching as "the art of asking questions", he had in mind the cut and thrust of lofty philosophical debate. The prosaic truth of the modern-day classroom is rather different. Four hundred questions a day may seem a startling statistic, but a large proportion of these (anything between 30 and 60 per cent) are procedural rather than learning-based. In other words, they tend to be of the is-your-name-on-it? or have-you-finished-yet? variety.'

TES Newspaper 4 July, 2003 |
Hastings, S. Questioning in TES,
4.7.2003



Feasey, R. in Skamp (2011) suggests that as teachers one of our roles in science is to help develop children to become scientifically literate individuals. The ability of a person to question and challenge science and the evidence it presents is crucial if he or she is to be able to participate in a democracy. Being someone who can use his or her knowledge and understanding and have confidence to ask questions is important.

For ourselves as teachers this means that we need to refine the art of asking questions so that they are scientifically focused. Feasey (ibid) argues that 'simplistic though this statement may appear, the reality is that, all too frequently, teacher questions in science lack this crucial component. The ability to ask the right question at the right time is probably one of the most difficult aspects of teaching. The essence of effective questioning in science is in the ability to link the linguistic form of the question to a scientific outcome.'

She goes on to suggest that teachers need to model for children:

- a range of question stems, for example, why?, what?, what if?, where?, how?, what do you think?, which?
- questions that are carefully structured, that is, questions that have a scientific outcome and appropriate question stem are more likely to be an effective question.

In addition to this, questions need to be sufficiently challenging in terms of higher order thinking skills; Bloom's Taxonomy (1984) indicates that such questions relate to:

- knowledge
- comprehension
- application
- analysis
- synthesis
- evaluation.

Questioning in science is ongoing, from the beginning when we elicit prior knowledge and understanding to challenging pupils to formulate questions that will help them take their own learning forward and then question children at the end of the process to reflect on their own learning journey.

What all of this requires is an environment where pupil questions are actively encouraged, promoted, challenged and celebrated, and there are many practical ways in which this can happen, for example:

- using Floorbooks (see <http://www.azteachscience.co.uk>)
- having a 'question of the week'
- hot seating where pupils ask questions of another child
- personal question / thinking books, where children jot down their ideas and questions in science both at school and home
- question boxes and mobiles
- games such as 'What am I?'

Whilst questioning is important, let's not forget that children should also be given the opportunity to answer their questions and also scaffolded into understanding the different ways that questions can be answered, for example:

- through observations (sight, sound, touch, taste, hearing)
- researching answers using books, internet, videos, leaflets, posters
- carrying out a fair test investigation
- interviewing an expert or talking with a friend
- thinking about what they already know to see if they can work out the answer using knowledge and prior experience
- trying something out to see if it works (exploration)

Reflect on

- What is the role of questioning in primary science?
- What is the role of the teacher as a questioner in primary science?
- What do you think are 'powerful questions?'
- How are questioning and curiosity linked?
- How could stories about scientists be used to encourage children to understand why questioning in science is important?

References, useful reading and links

Hastings, S. in TES Newspaper 4 July, 2003 | *Questioning in TES*, 4.7.2003

Skamp, K. (2011) *Teaching Primary Science Constructively (4th Edition)* South Melbourne, Victoria : Cengage Learning,

So far you've read about Activity Rich and Context Richness, so now it's the turn of the last element of the equation. By taking into account a 'Response-Rich' approach to developing a curriculum or lesson we feel that we can really do justice to our attempts to make teaching and learning more 'wonder-full'.

After reviewing many approaches to curriculum design, developed by teachers and by us, we acknowledged that a great deal of effort was being placed on getting the children 'hooked in' – engaged by a context for learning, and getting the children using a wide array of active learning strategies. Both those elements take a lot of effort and often it's because of that we may overlook the need to consider, 'How can I make the way children show or express their learning as full of wonder, engagement and relevance as I can?'

Are we really providing a diverse and 'rich' approach to the 'showing' of learning as we are with other aspects of the lesson?

During the Top Marks Project (AstraZeneca Science Teaching Trust Funded) 'Response Rich' exploited the use of ICT to help children communicate their learning.

In KS1 children's responses were shared through:

- Floor books – featuring children's work, photos of activities, questions and reflections
- Photostory – photographs with children talking through their learning experiences.
- Talk buttons and talking speech bubbles- to collect children's thoughts and ideas as they are formed.

In KS2 children's responses were shared through:

- Talking photo albums
- Films
- TV advert development
- Photostory

These methods proved fun and engaging for the children, and at times provided a steep learning curve for teachers and pupils alike. Children reported that using these methods meant that there was less need for just writing and teachers found the capturing of learning in these ways provided a rich source of assessment material.

Reflect on

- What are the range of ways you currently use to encourage children to share their learning in primary science?
- How would you say that you could further encourage a sense of awe and wonder through the processes children use to share their learning with others?
- To what extent does ICT play a role in the sharing of children's learning in primary science?

References, useful reading and links

View the AZSTT Continued Professional Development units for an interactive learning experience of the 3 riches - Context, Activity and Response Rich.

TTS has a wide range of electronic resources that are relevance to this section. Visit www.tts-group.co.uk



Scientific Enquiry – Scientific Inquiry

You may have noticed these terms used interchangeably, however the question is – Is there any real difference between the two?

Educators talk about '*enquiry*-based learning', which is characterised by 'learning through doing'. Others talk about '*inquiry*' which we can define through dictionary definitions as being about 'seeking for information by asking questions' (www.definitions.dictionary.net/inquiry). We may also understand an 'inquiry' to be a type of formal investigation.

Perhaps both have a role in primary science and that there is a connection between the two, children investigate, in its broadest sense, through engaging in hands on activity (*enquiry*) and use more formal, systematic approaches to answering their questions through *inquiry*.

Within hands on *enquiry* in the context of primary science there are different ways that children can 'inquire' by engaging in different types of activity. These have been recently reviewed in the 'It's not fair – or is it?' (2011) guide to developing children's ideas through primary science *enquiry*. Authors review 5 types of *enquiry*, namely:

- Observing over time
- Identifying and classifying
- Pattern seeking
- Research (surveys, using books, internet etc.) and
- Fair testing.

It's questionable as to whether 'pattern seeking' should be viewed as a separate form of *enquiry* – or whether the notion of 'exploring' would better suit this listing. After all, isn't looking for patterns just what science is all about? Of course, looking for patterns enables children in all sorts of *enquiries* to draw conclusions to take their knowledge forward.

Just consider the relevance of pattern seeking within a fair test investigation. Children collect data and consider the patterns within it. The same happens when they carry out and collect data as part of a survey, pattern seeking is an inherent part of the scientific *inquiry*.

When children explore they frequently repeat what they do, to see if it happens again and again to see if a pattern emerges. The role of pattern seeking in classification is unquestionable – seeking patterns is key to identifying similarities (rather than differences) between flora and fauna.

Within all of the activities associated with *enquiry* and *inquiry*, there is a continuum of development which children move along – from the naive enquirer, who has yet to develop complex ways of thinking and working in science, to the expert enquirer, who has the Personal Capabilities and subject knowledge to 'be strategic' in their search for knowledge and who can systematically pursue their goal through a range of different approaches.

The Wellcome Report highlights various key issues that are useful to review in this section.

- Ofsted comment that *inquiry* based learning has a positive effect on student enthusiasm and achievement (Success in Science 2008)
- Teacher preparation is key and must cover understanding about *inquiry*, as well as the necessary pedagogical content knowledge to teach through *inquiry*.
- A student's understanding about *inquiry* is more difficult to assess than other areas of the curriculum, as more importance is put on practical and thinking and reasoning processes
- Progression in *inquiry* means, for example, students making more rigorous observations, taking account of more experimental variables, analysing more complex evidence and ensuring that conclusions are more scientifically valid.



LOOKING FOR PATTERNS ENABLES CHILDREN TO TAKE THEIR KNOWLEDGE FORWARD

Reflect on

- Whether you think there is a difference between scientific 'enquiry' and 'inquiry'
- How can we ensure that engaging in these activities develops and extends children's scientific subject knowledge?
- What do you think of the points raised in the Wellcome Report?

References, useful reading and links

Turner J, Keogh B, Naylor S & Lawrence L (2011) *It's not fair – or is it? a guide to developing children's ideas through primary science enquiry*, Millgate House Publishers and Association for Science Education.

Wellcome Trust (2011) *Perspectives on Education: Inquiry-based Learning*, access online at http://www.wellcome.ac.uk/stellent/groups/corporatesite/@msh_peda/documents/web_document/wtvm053969.pdf [Accessed 28.5.12]

T

Talk as window into children's scientific understandings

'The easiest way of making an understanding is often through talk, because the flexibility of speech makes it easy for us to try out new ways of arranging what we know...'

Douglas Barnes, 1995

Talk is easy. Talking comes naturally to most children. Verbal communication begins at birth. From the first cry to the first word children engage in conversations that develop their understanding of the world. A cry evokes concern, a giggle is reciprocated with a smile and a defiant yell brings about confrontation. In the classroom, children can talk about what the world would be like if there was no disease and respond creatively without having to worry about spellings, punctuation or legible handwriting.

For teachers, talk is probably the most essential 'tool' of the trade. This was the focus on the DIPS – Discussions in Primary Science Project (managed by Martin Braund, University of York and funded by AstraZeneca Science Teaching Trust). Some insights from this work allow for teachers to consider the relevance of talk within primary science and indeed what we'd do without talk in learning. Of course we couldn't discuss, debate or ask questions! Talk is essential in developing a personal understanding of the world around us. This could be through direct conversations, egocentric speech or the silent conversations in our heads.

Neuroscientific research allows us to recognise that talk is not only essential for learning but is also necessary for developing the brain itself. At critical points in a child's development, 3/4 years and 10/11 years, the brain undergoes changes that shape the capacity to learn in adult life.

Talk is transitory. Children have the freedom to try out ideas without the fear of making mistakes. Thinking can be communicated immediately and reshaped based on the response of others. Often the current school system of evidence generation/collection in science still relies most heavily on paper based activities that can lack the spontaneity, and in-turn the 'raw' content, presented through talk. Through effective talk activities teachers can assess more accurately and therefore plan more effectively.

The style and function of talk changes as children develop cognitively. Piaget estimated that, up to the age of 7 years, 44-47% speech is egocentric, meaning that at this stage thinking is verbalised for all to hear. Social speech occurs later on when children develop the cognitive ability to internalise thoughts. Talk is then used as a mechanism to communicate thoughts and is less about the process of thinking. Teachers can begin to use talk to formatively assess children's understanding in science. You only need to be a classroom for short while to hear young children narrate every action as they carry it out, e.g. "I'm pouring the water on the sand, it feels cold". These overt sharings of thinking provide teachers with a window into children's understandings that can then help inform planning the next steps and provide materials to extend learning.

The shift to social speech occurs when children become more adept at controlling their verbal behaviour. Discussion between children and their peers provides further valuable insights into what children know and what they want to know about the world of science (See section D, page 12).

Paired and group talk is common practice in many primary classrooms and provides opportunities to explore and develop understanding in science. Whilst talk comes naturally to most children, the discussions they engaging in may not always be productive from a learning perspective, especially in a culture where we focus heavily on achieving teacher identified learning outcomes and success criteria. If children are unable to engage in meaningful talk the teacher must consider how best to scaffold discussions, for instance through probing questions (See section Q, page 38) or by modelling best practice through their own interactions and highlighting it in other children.

Of course, encouraging a 'climate of talk' within a classroom should ensure that children acknowledge that talk is valuable and valued, and that good learning is about being actively engaged with conversations, listening to and respecting one another's ideas is what good learning is about. They should be encouraged to recognise that learning is more likely to come through a discussion of understanding rather than a straightforward sharing of the correct answer.

Talk is so generic it's hard to consider why talk in primary science is more special in any way. Of course it's about far more than just a way of communicating expectations or giving instructions. Talk helps children to organise their thoughts and develop their understanding. The association between talk and scientific literacy and indeed personal capability is unchallenged – effective talk in primary science can enable pupils to ask questions, evaluate ideas and justify their conclusions. It can help children share their own theories about why things are as they are, what they're wondering about and indeed what their thoughts are about contemporary scientific issues.

Reading, writing and number may be the acknowledged curriculum 'basics', but talk is arguably the true foundation of learning.

Robin Alexander, *Dialogic Teaching* (2006)

Reflect on

- What do you think are the benefits of specifically emphasising the value of talking about science in your classroom?
- What could you refine in your classroom to further encourage pupil talk?
- How essential do you feel talk is within your current assessment processes in science?

References, useful reading and links

Alexander, R. (2006) *Towards Dialogic Teaching, Rethinking classroom talk, 3rd Edition*, Dialogos UK

Barnes, D., Todd, F (1995) *Communication and Learning Revisited*, London: Heinemann

Dawes, L. (2011) *Creating a Speaking and Listening Classroom, Integrated Talk for Learning at Key Stage 2*, David Fulton

For more on the DIPS project and other related work visit: www.azteachscience.co.uk/resources/cpd/talkingscience/view-online.aspx

www.azteachscience.co.uk/resources/continuing-professional-development/discussions-in-primary-science.aspx

TALK HELPS CHILDREN TO ORGANISE THEIR THOUGHTS AND DEVELOP THEIR UNDERSTANDING



Recent contemporary scientific developments which might at first glance seem inaccessible to children, and remote from their everyday life, are after more detailed consideration, essential to ensure that primary science offers contexts which:

- motivate
- capture imagination
- are relevant
- challenge perceptions
- illustrate applications and consequences
- indicate that science is a human endeavour.

Trying to ensure that children have access to contemporary contexts for science is challenging, finding out what is current, researching background science and adapting it so it can be successfully located within a curriculum takes time and imagination. Sometimes it is a case of 'we don't know what we don't know' particularly in an area such as science where human knowledge changes everyday. Let's take some examples, and at the same time, perhaps provide some inspiration for accessible contemporary contexts.

Biomimetics, do you know it is? It comes from the Greek words bios, meaning life, and mimesis meaning to imitate, so scientists often mimic nature to solve problems. One of the most famous was the design of VELCRO by George de Mestral; a Swiss engineer, who, on returning from a walk one day in 1948 and found some cockleburs clinging to his cloth jacket, he examined one under his microscope, it had thin strands with burrs (or hooks) on the ends an adaptation that meant the hooked part could cling to the fur of a passing animal. He used this idea to create a material which, on one side had stiff hooks like the burrs and the other side with soft loops like the fabric of his trousers. Hey presto! We have Velcro which now has hundreds of different uses and is commonplace in our everyday lives.

Other inventions include household suction pads which were inspired by the soles of tree frogs' feet and the tentacles of octopuses and even more surprisingly even garden plants provide scientists with new ideas, for example, nasturtium leaves have self-cleaning properties, drop of water on this leaf will roll off very quickly. A close look under a scanning electron microscope reveals why: there are tiny wax-covered bumps on the surface. Water hits the tip of the bumps which reduces the drop's contact so that the drop barely touches the leaf and runs off easily and takes dirt with it. It is through this kind of observation that scientists begin to understand the properties of materials in nature and replicate them for human use.

How about sharing this with children and asking them to imagine that they were the scientist who had just discovered this. What do they think it could be used for?

Scientists learn by observing, and nature can help us learn some basic principles of science and we can use this knowledge to solve problems and develop new inventions. It is important that children realise how scientists work and from where they gain their inspiration. As teachers it would be hard to keep up with the fast pace of change in science, and how can we introduce to ideas such as Biomimetics or nanotechnology (working at a molecular level)? How are we to know that scientists use ideas from nature to make materials such as self cleaning glass, sunscreens and even clothes that can clean pollution from the air? Well we aren't expected to, but we can be expected to keep up to date in our own professional area, and therefore know about resources such as Primary Upd8 (created by the Centre for Science Education & the Association for Science Education) which provides us with ideas and activities directly related to science in the news with children.

Whether it is the latest discoveries and inventions or how science is solving a human problem such as an oil spill Primary Upd8 makes science relevant using the power of topicality. Every week interesting science pops out of the news and popular culture. UPD8 creates a bridge from science to different areas within the science curriculum and areas across the primary curriculum. The aim of Primary Upd8 and its secondary equivalent (Upd8) is to create punchy activities that deliver content with maximum engagement without compromising sound pedagogy in science.

Upd8 also tackles the 'difficult or dull' topics in science so material is designed to make pupils mentally and emotionally involved, which as all good teachers know, makes it easier to grasp the ideas.

Turning news into high quality Upd8 activities every week means that there is material to engage pupils and develop their scientific capability in relevant and topical contexts. Using such resources enables the teacher to give children access how scientists work and the consequences of science on everyday living including ethical, social, political and economic issues.

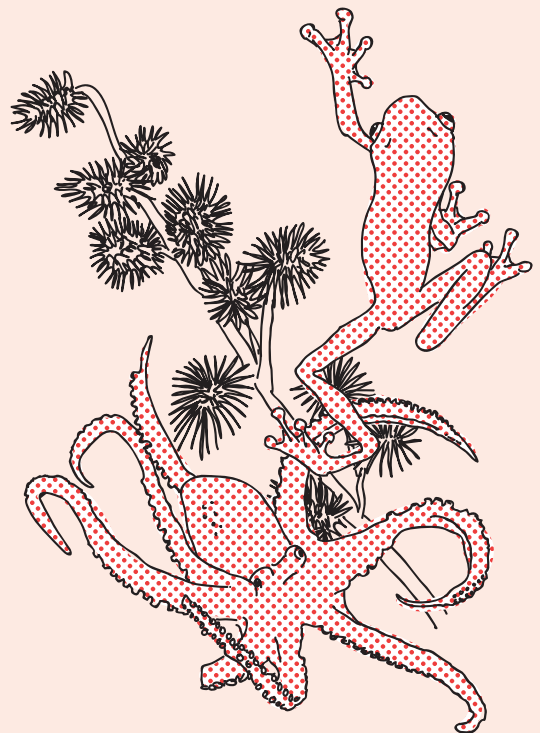
Reflect on

- What impact could using resources such as UPD8 have on a school's science curriculum?
- What aspects of your national curriculum does UPD8 meet?
- Why is it important that children understand how science influences our lives?
- Why is it important that children understand how the pace of change in our lives because of scientists and their work?
- How might introducing children to contemporary science and scientists help raise personal aspirations?

References, useful reading and links

www.primaryupd8.org.uk

**SCIENTISTS OFTEN MIMIC
NATURE TO SOLVE PROBLEMS**



V

Verbal Behaviour Analysis – it's all about Smart Talking!

VBA is a process through which the things people say are identified and grouped into categories. It provides us with an explicit recognition of what we say, how we say it and enables us to explore the implications of these verbal behaviour choices.

The Centre for Science Education has been working in partnership with Huthwaite International as a way of sharing knowledge between business and education. We have found that Huthwaite's research and approaches to VBA complement primary teachers work on speaking and listening and have relevance for children's collaborative work in science.

Since the 1970's Huthwaite have been researching verbal skills and their relationship to success in a wide range of jobs. Its research has developed a language for talking about interpersonal skills, namely verbal behaviour. There are different verbal behaviour categories:

Initiating	Reacting	Clarifying	Process control
Proposing (procedural and content)	Supporting	Testing Understanding	Bringing in
Building	Disagreeing	Summarising	Shutting out
	Defend/ attack	Seeking Information	
		Giving Information	

© Huthwaite International

Our partnership project

We wished to explore the application of VBA in primary classrooms a little more, and we valued the opportunity that the Yewlands Family of Schools allowed us. Project teachers in each school were trained by Huthwaite to use VBA to develop verbal skills in the classroom. Smart Science lessons were adapted to provide opportunities to teach and observe pupils' verbal behaviour skills. Teachers used a lesson study approach to trial different activities with their own class, as well as a master class for gifted and talented pupils from across the schools. Teachers worked together to plan, observe and feedback on generic tasks and science activities developed by Huthwaite and CSE.

This is one of our most recent projects and initial evaluations provided insights into:

Smart Science and VBA

Teachers felt that the use of Smart Science was a good starting point for introducing VBA. However, pupil understanding of the categories only came about when the skills were taught explicitly and success was greatly enhanced by the use of a VBA classroom wall display which could be referred to during the whole project. It was felt that more generic tasks to introduce VBA would have been beneficial. All teachers agreed that they felt that the timescale was too short to see any real longer term gains in the children's communication skills.

Gifted and Talented Master Class Event

Teachers and pupils agreed that this was a very positive transition event for children, with benefits for both KS2 and KS3 pupils. The focus on VBA and science really helped structure opportunities for dialogue whilst children were engaged in hands on science activities. The impact of this day could have been improved by ensuring all children had a more in depth understanding of VBA in advance of the lesson. The master class was an invaluable experience for all members of the project team in that it gave insights into the reality of introducing VBA into science lessons and future possibilities.

VBA IMPROVED CHILDREN'S ABILITY TO THINK OF AND BUILD ON IDEAS

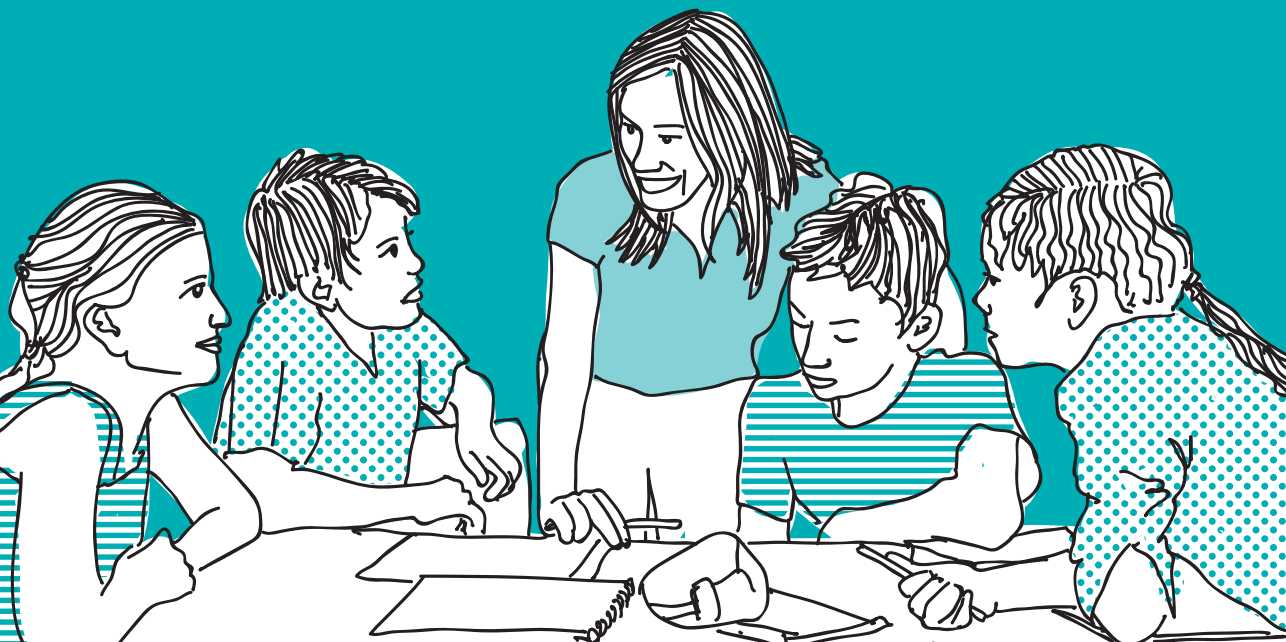
Reflect on

- What approaches does your school use to enrich speaking and listening in the curriculum?
- To what extent do you capitalise on those approaches in your primary science lessons?
- How do you feel about working with businesses as a means of providing inspiration for curriculum development?

References, useful reading and links

Extracts taken from

VBA Project Final Report 2010-11, Centre for Science Education



Goodwin (2001) helps us in understanding wonder, defining it in 3 ways that relate directly to the teaching and learning processes in science. He considers,

- wondering about: which reflects the activity of scientists, questions relate to how does it work? what would happen if?, why?, when? what next?
- wondering at: which reflects the human response to discoveries and understanding and, indeed, to our capability of 'wondering' and pertains to the exclamations like 'wonderful!', 'wow!', how interesting!, how fascinating
- wondering whether: which reflects questions that explore our values, moral and ethical judgments, should I do this?', 'Must I do this?' Is this right?, Why is this important?

Other writers talk of 'wow' moments in science learning, Feasey (2005) talks of the wow-factor in primary science and its direct interrelationship with creative science learning. She explores in very practical ways how children's learning can be filled with awe and wonder, focusing heavily on the role that investigative science and scientific enquiry has. Her recent work into learning outside the classroom (Bianchi & Feasey 2011) similarly explores strategies to enrich questioning, personal exploration and scientific talk within rich environments that provide opportunity for increasingly independent ways of learning and thinking.

Eccles & Taylor (2011) provide examples of wow events, some of which are teacher demonstrations, others free exploration by the learner, e.g. children observing what happens when mint Mento sweets are dropped into a bottle of Coke, or what happens with magic sand in water, or mixing cornflour and water into slime. Although fun in themselves and relevant to a primary classroom or home the focus here is on how such activities aim to grab children's interest for the key purpose of encouraging particular types of dialogue, in particular question posing, question musing and question answering.

What do children wonder about? We asked and found that children wonder:

Why do some bananas that are not ripe go a bit green? (Nathan, age 8)

Is fish meat? (Harrison)

What does alcohol have in it to make you drink? (Emily, age 8)

What's God's real name? (Spencer, age 8)

What is inside the Moon? What was the Earth before the big round solid ball? (Sam, age 8)

Is there such thing as a Big Foot? Have there ever been any UFO's? How are cow's milked? (Matthew, age 9)

What do the children in your school wonder about?
What do you wonder about?

What do you do with the wonderings of children?

The teacher's role

A crucial issue to address in this chapter is what happens when we spot children having these special wondrous and wonderful moments in learning. How does a teacher's role evolve in response to these events?

Often we experience moments of awe and wonder when we see or experience new things for the first time, things that are unexpected or perhaps challenge our preconceived ideas. Our role as teachers is not to try and 'do' much with the moments – that they are precious in their own right, and by possibly trying to jump into them, deconstruct and grab each one and move it on could spoil the moment. Should we say that our role as teachers, when these moments take place is to raise children's awareness of them, to acknowledge them and to plan for opportunities in the future that will support and extend it? That giving a wow moment its breathing space is in fact the best way to preserve the moment.

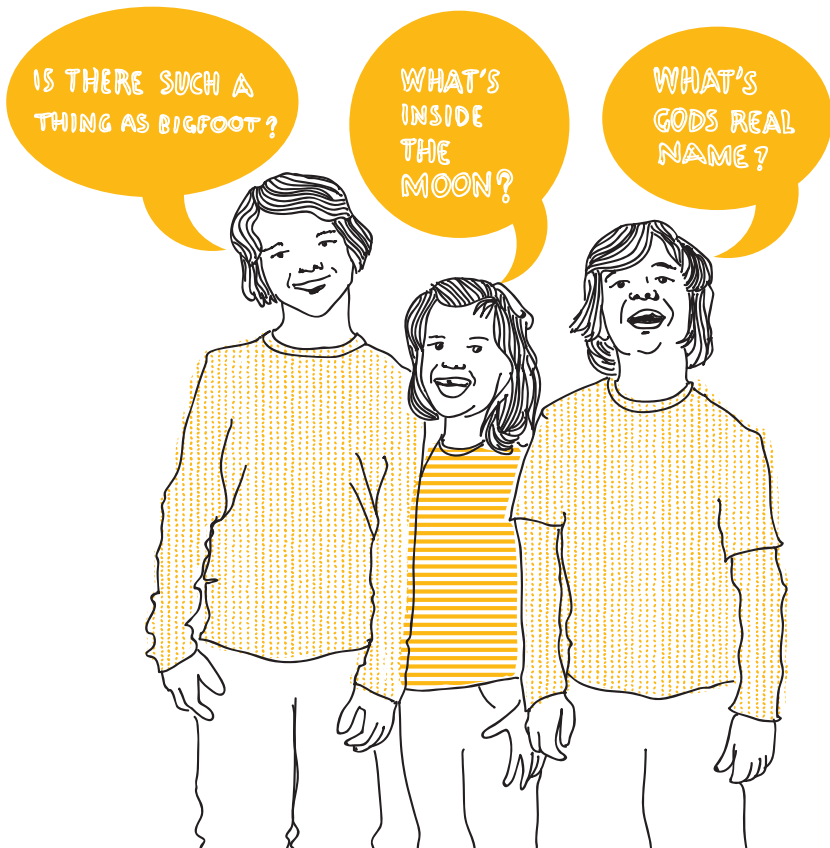
Reflect on

- What does the notion of 'wonder' bring to a science curriculum?
- How could children's wonderings influence the teaching and learning in your classroom?

References, useful reading and links

Goodwin, A (2011) *Wonder in science teaching and learning: an update*, School Science Review, 83 (302), Herts: Association for Science Education.

Acknowledgements to children and staff at St Thomas More RC Primary School, Rochdale, England.



X

X curricular

Barnes (2007:8) defines a cross curricular approach as being:

‘when skills, knowledge and attitudes of a number of different disciplines area applied to a single experience, theme or idea, we are working in a cross – curricular way.’

Lakin (2006) writes, there is a range of skills such as questioning, hypothesising, predicting, using observations, planning, conducting investigations, interpreting evidence and communicating, which are not unique to science and appear across the curriculum. Assisting children in transferring these skills from one subject area to another still remains key to successful science cross-curricular experiences. The ability to talk using appropriate vocabulary, role play, ask questions and work in a group or team are skills that can be practised during investigative and exploratory activities. The key issue for teachers is to acknowledge these opportunities and to plan actively to scaffold these areas of development. It is through these that children will acquire knowledge and develop understandings in and make sense of a topic.

Taking a cross curricular approach gives children the chance to see links between science and different areas of their learning and enhances their engagement and motivation for science. Bianchi & Thompson (2011) consider a range of approaches that are currently used within a cross-curricular approach, including:

making a link

This could be as part of a general lesson discussion, addressed in a relatively straight forward way, e.g. ‘Remember when we learnt about different types of materials and their properties in our science lesson, now look at the armour Roman soldiers wore, what were the advantages of metal armour for them and what could have been the disadvantages?’. This could be as short as a 5 minute conversation.

a topic or topic web

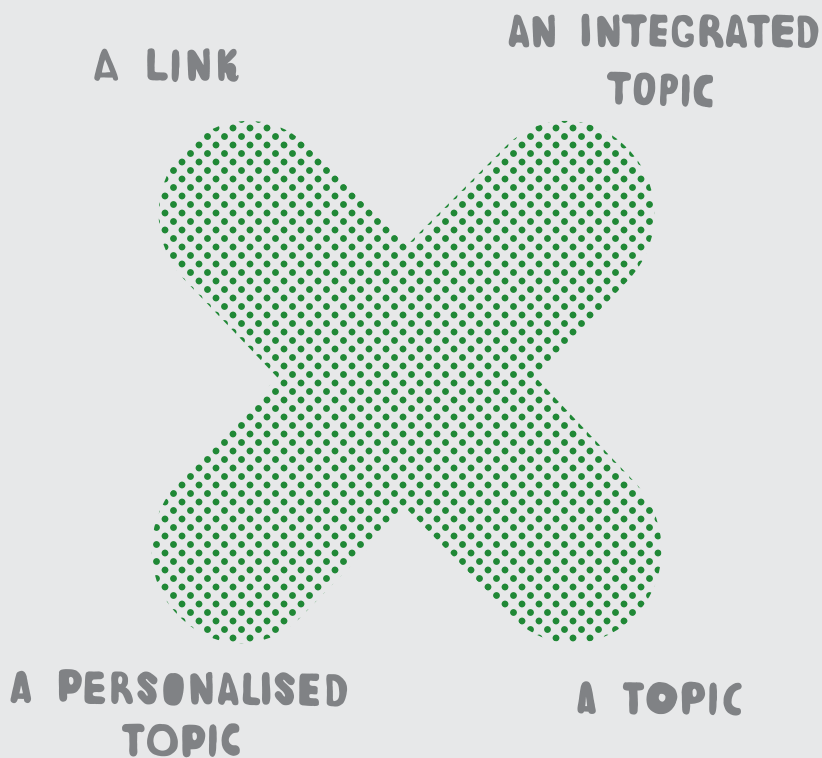
A topic name is found, based on objects (Toys, Plants), an occurrence in every day life (Summer, Christmas) or a theme (Health, Light, Monsters & Giants), or a story (Little Red Riding Hood, The Iron Man). These stimulate a holistic experience for the learner, however the curriculum design remains subject-defined with many being taught as stand alone and separate from one another.

an integrated topic

These still bring together subject learning under the umbrella of a theme or topic but subjects no longer sit side by side. Efforts are made to link areas of knowledge that share the same or similar modes of exploration and enquiry. Knowledge and skills development would aim to appear seamless to the children rather than compartmentalised into subjects.

a personalised topic.

This approach responds to the desire for a learner-centred approach to curriculum development. It goes beyond the teacher being the sole-decider of the topic themes and focuses on the children taking increasing responsibility for the context in which they learn and the content of their learning. Children are encouraged to suggest topics or choose from a selection, with the emphasis on capitalising on their personal interests by posing the questions and problems to be explored. Curriculum design becomes more flexible as subject boundaries are fluid yet opportunities for direct teaching used when appropriate. Subject knowledge and skills are drawn upon when they are relevant, and much focus is placed on exploring with the children ‘how’ they will go about finding out more or solving their problems. This approach is enriched by close relationships between home life and school life.



Jarvis, T. (2009, p. 40) recognises that teachers still struggle with planning for cross curricular science. She reinforces that we should not underestimate how important it is for a whole school approach to be firmly grounded in a set of principles which include, (ibid, 2011:59):

- a firm understanding of curriculum aims
- changing attitudes and gaining confidence takes time
- science coverage must be checked
- use only relevant associations between curriculum areas
- use a range of types of assessment
- begin with what promotes wonder and imagination in children's minds.

Reflect on

- What forms of cross curricular approach do you currently use?
- What do you find is most successful and why?
- How confident are you or is the staff that cross curricular is the best approach for teaching science?
- What do you see as the benefits of a cross curricular approach in primary science?
- How appropriate is it for science to be taught only through a cross – curricular approach or only in a subject specific way? What might a middle ground look like?

References, useful reading and links

- Barnes, J (2007), *Cross Curricular Learning 3-14*, Sage
- Lakin, L (2006) *Science in the whole curriculum*, in Harlen W (2006) *ASE Guide to Primary Science Education*. Hatfield: Association for Science Education.
- Jarvis, T (2009) *Pollen Project*:
www.pollen-europa.net
- Bianchi L & Thompson P (2011) *ASE Guide to Primary Science Education*. Hatfield: Association for Science Education.

How often when asked *'What do you do?'* have you replied *'I'm just a teacher!'*? It's likely that most of us often pass ourselves off as 'just' teachers, when in truth we are so much more.

Teachers, advisors, consultants, confidantes, managers, leaders, partners, collaborators, role models, councillor, researchers, learners, friends... which one are you? What else should be added to this list?

Of course teachers working in the 21st Education system today are expected to conduct roles well above that of 'just' encouraging learning in others.

We stand at the crossroads in primary science education, often wondering which way our government will send us and indeed wondering if it's the way we would have chosen or indeed is best for our youngsters. We reflect in staff rooms, cluster meetings, over the dinner table and in our hearts about what we would really like to see happen: we identify with precision where we feel the mistakes in the past have been made. Indeed we are already a lot like Donaldson, in his report about a future possibilities for teaching in Scotland, wishes us to be, as he promotes the profession to be: *'reflective, accomplished and enquiring professionals who have the capacity to engage fully with the complexities of education and to be key actors in shaping and leading educational change.'* (ibid p 19)

It is welcoming to read the Scottish view and to feel a sense that many of us have been moving down the right path using our own innate wisdom, when encouraging teachers and clusters of schools to try out innovative ideas related to improving the experience of learners in science. In fact, with the backing and support of a wide range of funders, including the Comino Foundation, local authorities, and the AstraZeneca Science Teaching Trust, the approach we use at The Centre for Science Education to teacher-informed innovation and development is a positive way forward.

You may think you aren't part of this community of researchers, but if you are in the classroom and reflect upon your lessons, then of course you are. It may be too long winded to say that you're a 'reflective practitioner engaged in critical and grounded action research related to the teaching and learning of science', when asked what you do, but as a teacher, by default – you are, and so you should be proud to say it and supported to do it! We have one of the most powerful roles to play in the development of our youth, don't we? In a fast moving world where time passes so very very quickly, I urge you to do something that restores your commitment to doing more than 'just' teaching – download the Donaldson Review perhaps, explore the AstraZeneca Science Teaching Trust CPD Units, find out who we are at the Centre for Science Education and see if there are any projects you'd be interested in learning about. And when you've done that, share it with someone else...



Reflect on

- What areas of primary science innovation are you inspired by?
- What learning have you had in your classroom and professional life that you would like to share with others?

References, useful reading

Primary Science by the Association for Science Education (quarterly journal with articles by teachers for teachers).

Donaldson G (201) Teaching Scotland's Future, Scottish Government, Edinburgh. Access at <http://www.scotland.gov.uk/Resource/Doc/337626/0110852.pdf> [Accessed 28.5.12]

For many years the Comino Foundation has supported the work of the Centre for Science Education. The Comino Foundation was established by a highly gifted engineer called Dimitri Comino in 1971. He was committed to making things and to making things better. Ahead of his time, in his companies, he worked with all employees to raise aspirations and to encourage achievement. His starting point was a desire to help people be more effective.

The Foundation encourages and supports innovative ventures designed to enable people to function more effectively and thrive. It looks for better ways of developing people's capabilities, their capacity and desire to make things happen – their zest, and appetite to learn, to create, to change things for the better, for themselves and others.

For the CSE this close relationship over many years has provided opportunity for much in-depth exploration into the notion of developing youngster's personal capabilities and leadership skills. From professional standpoints it has provided chance to network and open conversations with a wide variety of groups and organisations. Over the years it is clear that the way in which the Foundation supports our work is often through providing time for us to pursue new ideas, opportunities and indeed to follow our 'dreams' or professional desires. As such, staff have the space to innovate, explore and experiment with new ideas in the world of Science Education.

The idea of 'dreamtime' is central to creativity.

In the busy, ever-changing world of education, we may feel that time is of essence, that even time is our enemy, but imagination and therefore creativity requires it.

Ueland offers us a lovely term in 'moodling', which she describes as long, inefficient, happy idling, dawdling and puttering. We feel that this a valuable way to end this booklet, as many of the ideas and thoughts presented will require some 'moodling', some time to allow the writings to sink in. You never know, your thinking may lead to a desire to make a change or do something different, it may lead to a new passion or dream that you wish to chase.

In a lot of ways we really hope it does. All be it a whistle stop tour of Primary Science it encourages us to reflect and think about new ideas and our practice.

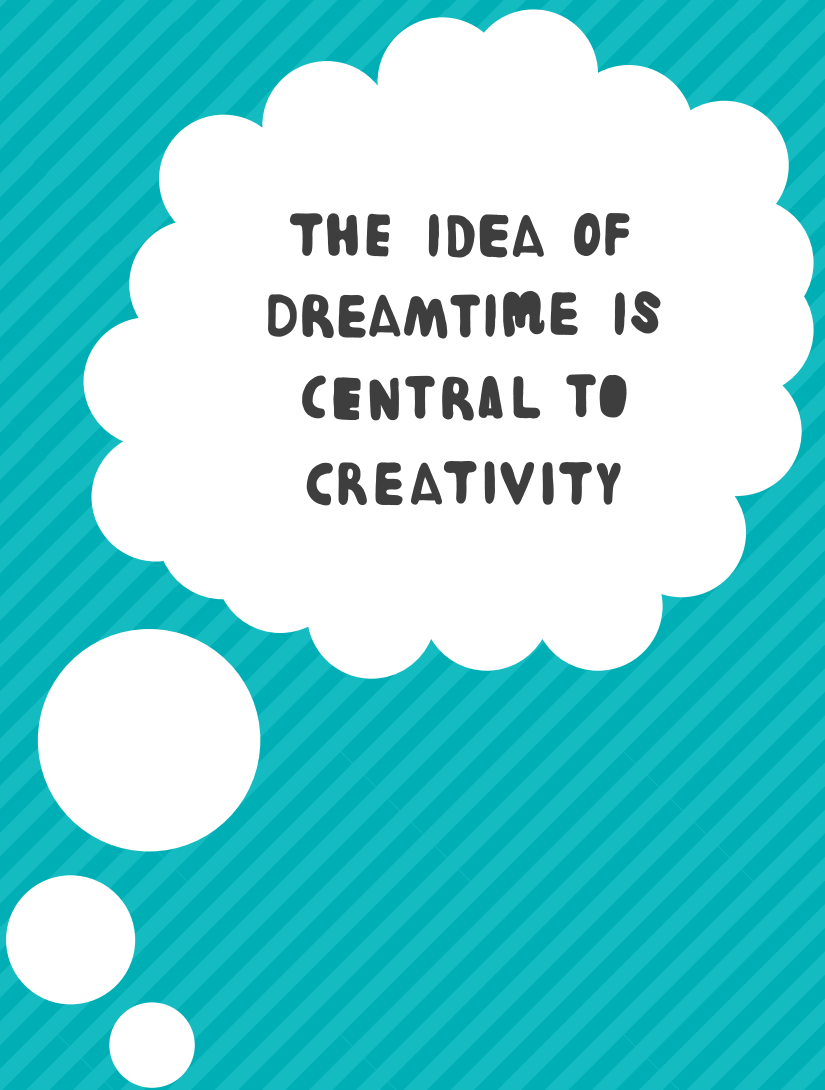
As teachers we need this time out in order to consolidate our approaches, but let's not forget those who are always the most important in the learning process in schools – the children themselves.

- Do we offer them enough time to stop and stand still?
- Do we offer them enough time to dream?
- Do we offer them enough time?

Coleman (1993, p.63) reminds us that children too need time out in science, so that they can be creative and enjoy what science has to offer them.

It's a terribly frustrating thing to be stopped when you're in the middle of the process. But we live in such a hurry-up way. So again and again children are stopped in the middle of things they love to do. They are scheduled. There isn't time for children to relax into their own rhythm.

So to move forward in science education both adults and children we must all have time to stop, time to stand still away from our scheduled lives and to muddle, talk and of course never stop 'Zzzzzzzzz' dreaming about future possibilities.



**THE IDEA OF
DREAMTIME IS
CENTRAL TO
CREATIVITY**

Reflect on

— What are your dreams for the future?

References, useful reading and links

Coleman, D. Kaufman, P. & Ray, Michael (1993) *The Creative Spirit*. A Plume Book: New York.

Sternberg, J. (Ed.) (1999) *Handbook of Creativity*. Cambridge: Cambridge University Press

http://thinkexist.com/quotes/brenda_ueland/

The Comino Foundation, www.cominofoundation.org

The aim of this booklet is to provide a starting point for reflection and discussion on issues in primary science education, for example, it could be used:

- for reflection on your own approaches to teaching and learning;
- as a starting point for discussion with colleagues;
- to initiate debate within your own school or a family of schools.

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