

## Teaching Primary Science Constructively



**Or how do we make sense of our world?**

**A discussion of Constructivism as a theory of learning and its application to Science in the Foundation Stage and Primary School.**

**Gordon Guest**

**UWE, Bristol  
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**(edited very slightly by Alan Goodwin and Keith Ross Aug 2004)**

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<Discussion of Constructivism> Authored by Gordon Guest, UWE, Bristol accessed from [http://www.ase.org.uk/sci-tutors/professional\\_issues/teaching\\_teaching/misconceptions.php](http://www.ase.org.uk/sci-tutors/professional_issues/teaching_teaching/misconceptions.php) date created Aug 2004 page <1> of <24>

## Constructivism.

Constructivist learning is based on student's active participation in problem solving and critical thinking. Learning is an active process in which learner's construct new ideas or concepts based upon their current ideas or past knowledge. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on their own developing cognitive structure to do so. They are constructing their own knowledge by testing ideas and approaches based on their prior knowledge and experience, applying these to a new situation, and integrating the new knowledge gained with pre-existing intellectual constraints.

People learn best when they actively construct their own understanding.

In constructivist thinking, the context, the beliefs, and the attitudes of the learner also affect learning. Learners are encouraged to invent their own solutions and to try out ideas and hypotheses. They are given the opportunity to build on prior knowledge and, maybe to disagree with or withhold judgement about what they learn from teachers or other 'authorities'?

### Science and Constructivism.

*The great achievement of the sciences, over the past three or four hundred years, has been to tell us important and interesting things about ourselves and the world in which we live. The sciences by no means tell us everything, or even the most important things we want to know about the world. But what science does, uniquely, is to offer a knowledge that can be relied upon for action. This reliable knowledge is much more than a compendium of things that happen to have been observed; it presents the world in novel and surprising guises, saying that things are in reality often not what they seem to be. Science tells us, for example, that diseases are carried by micro-organisms invisible to the naked eye; that heritable traits are carried by a chemical code, that all substances are made of tiny particles held together by forces which are electrical in nature. –*

*Acting on the reliable knowledge which science has produced, scientists have developed a staggering variety of artefacts and products, ranging from electric motors to antibiotics, and from artificial satellites to genetically engineered insulin for treating diabetes, which have transformed our lives and lifestyles as compared with those of past generations. “* (Millar & Osborne 2000 S4.1)

So thinking and working scientifically emphasises an approach, which seeks to adopt some of the ways in which scientists construct and acquire knowledge.

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Harlen (1996 p2) suggests that this narrow view of science is:

- Objective
- Capable of yielding ultimate truths;
- Proving things;
- Having a defined and unique subject matter;
- Having unique methods;
- Being value free.

Scientists need to be able to do certain things such as use equipment, measure effects and create tables and graphs. These are the mechanical skills a scientist needs to master to work scientifically. Popper (1963) classes this as the 'checkwork' side to science, which comes after the 'guesswork' side where ideas are created (Ross et al 2004).

**In the classroom these 'checkwork' activities include: -**

- Using equipment
- Measuring
- Recording information including **drawing tables** (a requirement for Y2 to Y6 in the QCA Science scheme)
- Communicating information including drawing and explaining graphs.

**Additionally scientists need to be involved in the "thinking behind the doing".**

Central to scientists thinking and ways of working is the need to create a set of evidence, which is believable and therefore acceptable to others. They need to ask;

- What will I have to think about doing to collect data (evidence) to help me solve my problem or answer my question?
- What will I have to think about doing to make sure that my evidence (data) is believable to others and/or myself?

Harlen (1996 p2) suggests that where science activity broadens to explore ideas and concepts rather than just test them then science may be seen more holistically as;

- A human endeavour to understand the physical worlds
- Producing knowledge which is tentative, always subject to challenge by further evidence;
- Building upon, but not accepting uncritically, previous knowledge and understanding;
- Using a wide range of methods of enquiry
- A social enterprise whose conclusions are often subject to social acceptability;

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➤ Constrained by values

Gott and Dugan (1995) refer to this as -  
**“concepts of evidence”**

A constructivist model of learning argues that individuals experience a dynamic interaction of sensory perceptions, memory of previous experience and cognitive processes, which shape our understanding. In this model individuals actively construct meaning in order to make sense of the world around them.

Frequently these pre-scientific views drawn from common sense are old fashioned, naïve and incorrect even though the logic of development makes sense. For example a young child argues that “orange objects float”. They relate this assertion to the orange armbands they use in the swimming pool. The class teacher needs to provide activities, which challenge this viewpoint, and enables a more scientific explanation to be constructed.

Goldsworth and Feasey explore the issues of structuring children’s science work in detail. They suggest a strategy of having structured planning boards for KS1 and KS2 to enable children to focus on their investigation question and so reduce the number of variables. (*Anne Goldsworthy & Rosemary Feasey (1995 & 1998) in Making Sense of Primary Science Investigations. ASE publications.*)

A fundamental difference between scientific evidence and that of other subject disciplines such as History is that science investigations can be recreated and repeated, whereas in History it is not possible to accurately recreate the siege of Bristol during the English Civil War. History is subject to interpretation. In science the evidence ought to be repeatable to substantiate the interpretation.

**Where children work without any understanding they do so at only a mechanistic level, superficially going through the motions of doing and using skills that sometimes characterise primary science practical work and comprise nothing more than busy work.**  
(Skamp 1999 p37)

The history and philosophy of science show that scientific knowledge is constantly changing in the light of new evidence and ideas. (Popper 1963, Hawking 1988 and Littledyke 1998). Therefore constructivism is generally accepted as today’s scientific theory of learning and philosophical rationale.

**This change in viewpoint has classroom implications for those teachers “Educated” under a different rationale and who have not yet adjusted to new views.**

Many science educators in the United Kingdom, United States, Australia, New Zealand and Scandinavia share a fundamental belief about Science Education.

1. That effective primary science will facilitate children changing their ideas so that they can make better sense of the way in which their world works.
2. An emerging key role for science is that of creating a scientifically literate population “ a populace who have sufficient knowledge and understanding to follow scientific debates” (Science Beyond 2000)

The interpretation of learning science, in 1 above, which underpins this belief, views learning in science as;

- **A learning process which develops conceptual change in the learner**
- **It acknowledges that children from an early age (before they come to school and out side of school when at school) continually construct their own ideas about how the world works**
- **Children’s & student’s learning involves the interaction of these ideas with the input of further experiences and ideas.**
- **To learn in a constructivist sense implies that the ways in which teachers encourage children to change their ideas is a critical issue. Crucial to this is which ideas they want pupils to adopt!**
- **To support children’s learning teachers need to know, use and understand a wide range of teaching strategies.**

However McClelland comments that although children bring to school a great deal of knowledge and experience it is not usually highly elaborated and is disorganised thus schooling has a major function in helping this **knowledge to become more complex and organised.** (Littledyke 1998 p11)

To support children’s learning in science, science lessons can be taught in a variety of different ways – not all of which are compatible with constructivist ideas. Marilyn Flear & Sue Atkinson in **Science with Reason** (1995) provide a very good summary of teaching styles and their relationship with Primary Science.

- **Process approach**
- **Interactive approach**
- **Transmission approach**
- **Discovery approach**

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In addition to the teaching styles adopted by the class teacher the classroom organisation also makes a difference on learning. Are the children to be taught as a whole class, as groups, as ability groups, all at the same time on a related theme. Each of these teaching strategies influences how the child learns.

**The table below suggests some of the variations possible. It is adapted from the Science 5 to 13 Science project.**

<b>Method of organising</b>	<b>Advantages</b>	<b>Limitations</b>
Whole class. Teaching by “chalk and talk” and demonstration.	Minimum organisational demands. Economical on time and equipment.	No first hand experience for children. No allowance for individual ability of pupils. Difficult to involve whole class.
Whole class practical. Children work in small groups doing similar tasks.	Relatively easy to plan ahead. Children can work at their own pace if extension work is available. Equipment demands are known in advance. First hand experience for pupils. <b>(According the SPACE project research children learn more slowly but in more depth through first hand experience. The knowledge sticks.)</b>	Preparation of extension work. Follow up lines of enquiry difficult. Quantity and duplication of apparatus involves much setting out and clearing away. <b>(It also assumes schools have sufficient science resources for whole class activities!)</b>
Thematic approach. Small groups working independently to contribute to the whole. Each group is doing a similar task but the questions may be different <b>(Remember the video on dissolving)</b>	High in interest and motivation. First hand experience for all pupils. Children work at their own pace. Builds confidence in communicating skills when reporting back. <b>(Encourages more independent learning).</b>	Difficult to arrange balanced cover of science experiences <b>(will all children be supported in learning the same things about magnetism?)</b> Difficult to arrange balanced cover of science experiences. Difficult to ensure coherence and understanding from report back.
Circus of experiments. Small groups of children rotating around a set of prescribed activities.	Easy to plan ahead, less demanding on apparatus than a whole class session, and all children can use specialist items. High in interest and motivation.	Activities cannot be sequential. Occasional pressure on completion time before change over. Difficult to organise report back on whole circus. Method of briefing essential.

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Small groups or individuals. Areas of study chosen by themselves.	Allows variety of interests. High on motivation. Children work at own pace and own potential.	Demanding on teacher. Structured framework necessary. Stretches schools equipment and resources.
<b><i>Whole class. Worksheets and text books.</i></b>	<b><i>Ease of providing material. All children get the same it's quick to provide. No clearing up or packing away.</i></b>	<b><i>Low in interest, low in motivation (if done repeatedly). No hands on to underpin learning of concepts</i></b>

Adapted from Science 5 to 13 with Objectives in Mind 1972  
(NB Italics are my commentary G. Guest 2001)

The research base makes it very clear that **one off science lessons do not encourage effective conceptual development**. Nor does teaching which ignores practical hands on work as a part of the teaching sequence. There need to be both a continuing and meaningful 'story' and a practical engagement with the subject matter.)

- **Clearly this places a major focus on teachers planning and implementing a series of sequential lessons to support science learning.**
- **It may be that part of that sequence develops children's use of a particular science process such as; - fair testing or observation**
- **The use of applied science (Design and Technology) such as making and using vehicles to enhance a topic on movement also facilitates conceptual change**
- **Science processes should not be separated from content and children need guided and structured science activities to help them learn**

Thinking and working scientifically requires in part, a focus on understanding science ideas in order to make sense of our world, but also an appreciation of the way science derives those ideas and the forms of evidence it accrues to substantiate them.

Science understanding, and being scientifically literate means being able to apply science processes, skills and attitudes while working with the scientific ideas (concepts) that help us make sense of our world. The National Curriculum 2000 (DfEE 1999) discusses Scientific enquiry rather than specific process skills. Harlen (1977) and Guest (2001) explore process skills in more depth in the appendix.

The science evidence is equally clear that children and adults use real life experiences to help make sense of scientific phenomena.

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- *For example an old wives tale from the days of universal coal fires was that the fire was less hot in daylight because you could not see the flames. So many people closed the curtains when the fire was lit! It is suggested today that drinking a pint of milk before drinking alcohol prevents one becoming drunk!*

It is interesting to note that in **September 1896** the Daily Telegraph had a lead front page article “**Does electricity cause blindness**”.

**This was a science scare story of the time; over 100 years later we know that this is not true. So science can both raise concerns and solve them, but this brings into play notions of ethics and value systems.**

It is equally clear that many children, students and adults still hold many “misconceptions” about science. A more appropriate description is perhaps alternative framework; -

- **because it refers to experience based explanations constructed by the learner to make a range of natural phenomena and objects intelligible**

For teachers, determining the alternative conceptions that learners hold is critical to support further learning in science.

There have been numerous studies on Misconceptions or Alternative frameworks, such as; -

- Liverpool University S.P.A.C.E. project 1990 – 1998
- Oxford University Children’s Learning in Science project 1990 – 1998
- Nuffield Primary science
- A range of articles in journals e.g. Primary Science review

**Alternative conceptions have some clear characteristics, these are; -**

1. Learners come to formal science instruction with a diverse set of alternative conceptions concerning natural objects and events.
2. The alternative conceptions that learners bring to formal science instruction cut across age, ability, gender and cultural boundaries.
3. Alternative conceptions are tenacious and resistant to change by conventional teaching strategies.
4. Alternative conceptions often parallel explanations of natural phenomena offered by previous generations of scientists and philosophers.

5. Alternative conceptions have their origins in a diverse set of personal experiences including direct observation and perception, peer culture and language, as well as teachers explanations and instructional materials
6. Teachers often subscribe to the same alternative conceptions as their students. **Be warned!**
7. Learners' prior knowledge interacts with knowledge presented in formal instruction, resulting in a diverse set of unintended outcomes.
8. Instructional approaches that facilitate conceptual change can be effective classroom tools.

Constructivism as a model of learning argues that “**students – and teachers - construct rather than absorb new ideas**” and that learners actively generate meaning from experience.

### **Some examples of how the learner constructs misconceptions.**

**Children's prior ideas interact with teaching.**

#### **Example 1. Light.**

Interviewer: Can you tell me, Lisa, where there is light?

Lisa From the sky.

Interviewer Where does it come from in the sky?

Lisa From the clouds.

Interviewer What do you think makes the light in the clouds

Lisa: God.

Interviewer: How does he do that?

Lisa: He does.

Interviewer: Is there light anywhere else?

Lisa: If we mix colours?

Interviewer: If we mix colours?

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Lisa: Yes. If you mix white and blue you get light blue and if you mix red and white you get light pink

**Children can construct unintended meanings.**

ASE (1990) Children's Learning in Science Project

**Example 2. Chlorophyll**

Student: It's gone green, hasn't it?

Researcher: So it's gone green because you put the iodine on. Is that what you're saying?

Student: Well, my conclusion for that job was that iodine.

Student: Makes it go green

Student: Puts back the colour

Student: .... Chlorophyll

All: Puts back the chlorophyll

Researcher: Iodine puts back the chlorophyll?

Student: yeah!

Student: Conclusion. Meths takes out the chlorophyll from plants. Iodine puts back the chlorophyll.

Student: Well, I don't know what it does, but it's gone, definitely gone a different colour.

ASE (1990) Children's Learning in Science Project

(This is the well-known secondary science 'experiment' where living leaves are partially exposed to sunlight, then (following removal of pigment) tested for starch. There is so much 'clutter' in the experimental procedure that few students realise that it is supposed to link exposure to light with build up of starch)

As Osborne and Wittrock (1985) state; -

*People tend to generate perceptions and meanings that are consistent with their prior learning. These perceptions and meanings are something additional both to the stimuli and the learners' existing knowledge. To construct meaning **requires effort on the part of the learner** and links must be generated between stimuli and stored information.*

It is now known that just as many children in secondary schools do not change their ideas about how their world works while at school and some pre-service teachers complete their teacher education degrees and do not change their views about teaching and learning.

### **So how do we help students and ourselves to construct more scientific ideas?**

Ausubel (1968) stated that we need to ascertain where the learner is and teach accordingly. **Elicitation** of learner's ideas is a prerequisite to modifying and changing their alternative conceptions. (*For more details on elicitation look at Ritchie and Ollerenshaw 1997 Primary Science making it work*)

Ausubel further suggested that well motivated children may fail to learn because the curriculum makes demands on their conceptual knowledge with which they are unable to cope, i.e. it ignores their alternative frameworks.

#### ***Ausubel posited three conditions, which are necessary for meaningful learning;***

- 1. The material itself must be meaningful; it must make sense or conform to experience. (It does not have to be true)*
- 2. The learner must have enough relevant knowledge for the meaning in the material to be within her/ his grasp.*
- 3. The learner must intend to learn meaningfully, that is she / he must intend to fit new material into what she he already knows rather than memorise it word for word. (Littledyke M. 1998 p10)*

**All constructivist learning models and strategies are founded on the principles presented by Ausubel.**

Piaget (1896 – 1980), proposed that the structure of children's thinking covered four stages; -

- **Sensori motor.** A period covering the first two years of life;

- **Pre operational.** This is further subdivided into the pre-conceptual stage and the intuitive stage. A period of infancy when the child moves from an intuitive, pre-logical grasp of reality to a logically constrained more realistic view of the world at about 7.
- **Concrete operations** .A stage developing through internalised mental learning through using concrete activities until about 11
- **Formal operations.** The more abstract formal operations where children manipulate abstract concepts from about 12.

***(Note see the appendix to see how Science 5 to 13 translated Piagetian stages into expectations of children's learning in science).***

Piaget challenged the view that all learning was hereditary. Whilst his specific investigations have been challenged (E.g. Donaldson 1982). Piagetian Theory does provide explanations for some of children's learning. (see Glassman W. 1995 Approaches to Psychology p275 & Goswami 1998 Ch 8)

Vygotsky (1968) and Bruner (1990) emphasise that **social and cultural factors** will have an impact on the ideas that students construct. Vosniadou (1997) drawing on work from Samoa and Greece tentatively suggests geographical location may also have an influence.

Vygotsky further argued that students could learn through instruction. That is you could "scaffold" the learner's development and the gap between learner's assisted and unassisted competence is the **Zone of Proximal Development.**

### **Some of the learning styles that apply to children.**

Allen (1998) suggests there are four major learning styles and all have strengths, weaknesses and methods to strengthen them.

For example;

#### **The Activist**

##### **Strengths ....**

- flexible and open minded
- happy to have a go
- optimistic about anything new and therefore unlikely to resist change

Children who are activists are likely to be good at carrying out investigations.

#### **The Theorist:**

##### **Strengths ...**

- logical "vertical" thinkers
- rational and objective
- good at asking probing questions
- disciplined approach
- 

Children who are "theorists" are likely to be good at observation.

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**The Reflector: Strengths...**

- careful
- thorough and methodical
- thoughtful
- good at listening to others and assimilating information
- rarely jumps to conclusions
- 

Children who are “reflectors” are likely to be good thinkers and organisers.

**The Pragmatist: Strengths....**

- keen to test things out in practice
- practical, down to earth, realistic
- businesslike, gets straight to the point
- technique oriented

Children who are “pragmatists” are likely to be good problem solvers.

**In part this learning process links with how well children use their memory and what skills they have been taught in using their memory.**

Two of the most well established principles of human memory are that **“rehearsal”** is a powerful aid to deliberate memorisation and that the **imposition of some structures** or meaning on what we seek to memorise also determines the likelihood of successful recall. (Wood 1991 p57)

Within science this could be translated into the **“play period with experimental equipment”** and then the **structured investigation** or focus on using a particular process skill to assist concept development.

Analysis of children’s responses to science questions in the KS2 SATs clearly shows children need both practical activities and the opportunity to come back to the same concept to explore it further. A process equally important in the Foundation Stage, Key Stage 1 and Key Stage 2. The CLEAPSS primary science newsletter (number 27 autumn 2003 p4 –5) neatly summarises some of these issues.

**So the practical science activity acts as a focus for using multiple mental learning strategies.**

However Wood (1991 p31) refers to the complexity of learning multiple stimuli (or ‘chunks’) at once. Many adults can cope with between five and seven multiple stimuli at once, some exceptional learners such as Einstein and Margaret Thatcher cope with nine.

Nursery and Infant children can learn to manage 3 such stimuli and some junior children cope with 4 or 5. In the initial stages of learning lots of separate ideas 'fill up' the available slots in the processing memory – later they are combined into one thing and thus can be processed more efficiently. E.g. C A T is initially three separate letters – but then becomes the word 'cat' and eventually carries with it a large number of attributes that relate to 'catness' (living, furry, four legs, vertebrate, mammal etc.)

**What this means for science teaching is that;**

- **Children need a structured series of science lessons**
- **They need practical activities to help “cement” the concept mentally**
- **The activities should not involve too many stimuli, or the stimuli should be built up over a period of weeks**
- **The teacher needs to act as instructor encouraging self engagement by the child but also explaining and directing how to progress.**
- **As children gain understanding and skills they can process more information from a science activity. (For more detail see Guest and Postlethwaite 2000)**

**This approach may be summarised as the interactive teaching approach, which is seen as different from; -**

- Discovery learning
- Enquiry learning
- Process skills teaching
- Developmental (associations with Piaget's stages of learning suggesting that children can not learn X because they are not yet ready. The new 2000 curriculum does just this allocating “balanced forces” to KS3 arguing (falsely?) it is too complex for KS2
- Information processing (see Wood D.)

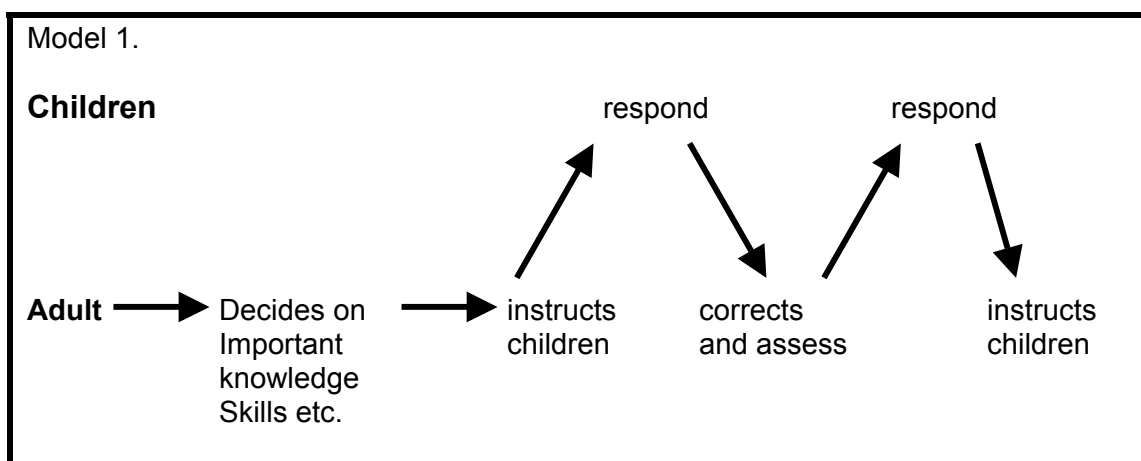
***(These ideas of learning in science link with the Y3 GPS module, which explores effective teaching and assessment and considers some learning theories)***

Developmental learning links with both Piaget and Bruner who saw intelligence developing through stages. The National Curriculum 1989, 1991, 1995 and the new 2000 curriculum does just this allocating “balanced forces”

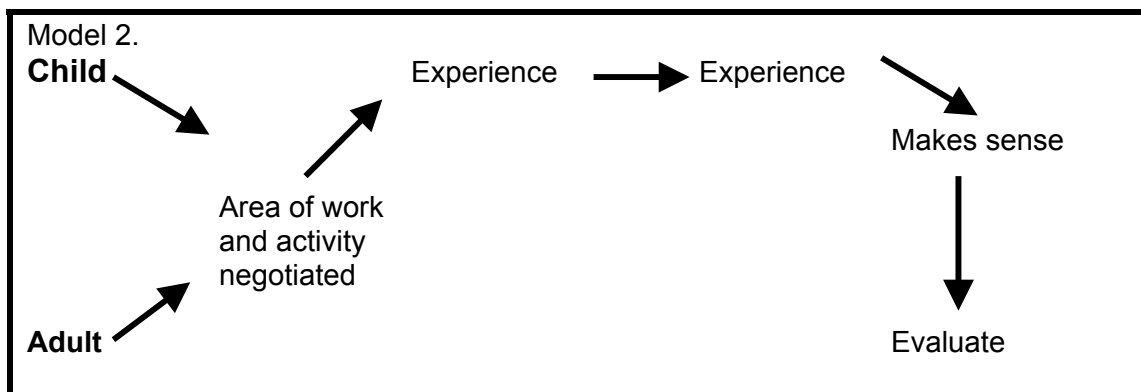
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to KS3 arguing it is too complex for KS2, whilst the Foundation Stage curriculum emphasises skills and processes with concepts coming later. The notion of Forces being taught in Y2, Y4 and Y6 also reflects Jerome Bruner's ideas on the spiral curriculum. That the same concepts need to be returned to again and again at ever more complex levels. Analysis of the KS2 science SAT answers by the QCA has emerging evidence to support the importance of this spiral of learning in science.

The table below, developed by Pollard (1997) indicates three styles of learning, the behaviourist, the constructivist and the social constructivist. The suggestion is that the learner progresses differently in each model.

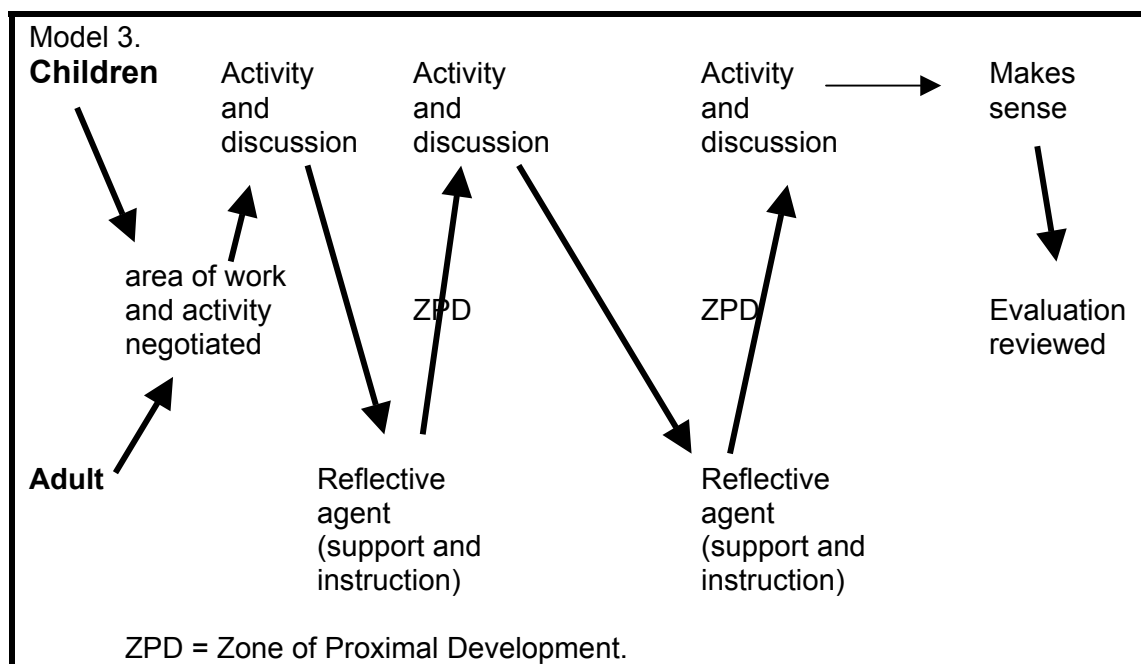


Model 1. A behaviourist model of roles in the teaching – learning process



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Model 2. A constructivist model of roles in the teaching – learning process.



Model 3. A social constructivist model of roles of the teaching learning process<sup>1</sup>

(From: Pollard A. (1997 3<sup>rd</sup> Edn.) *Reflective Teaching in the Primary School*. London: Cassell)

Harlen (200 p16) suggests that information processing involves;

- Reasoning skills
- Enquiry skills
- Creative thinking skills
- Evaluative skills

**So teaching science in the primary School will involve an interconnection between learning theory, styles of learning and teaching, classroom organisation, and the use of particular science skills.**

(Note see appendix for various lists of skills)

This then suggests that each learning style has strategies that would enable the learner to develop in a particular way.

**Some of the specific constructivist teaching strategies and techniques are;**

- elicitation
- discussion
- concept maps
- encouraging the planning of investigations

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- activities to test children's hypotheses
- predict – observe – explain (**POE**) procedures (see Guest 2000)
- group work
- whole class work
- learning science procedures e.g. fair testing
- applying cognitive thinking skills to evaluate procedures
  
- **linking** these “school based” procedures with everyday experiences outside school to “construct” meta cognitive thinking skills.

**This list can now be related to familiar science activities discussed in previous science sessions, such as; -**

- **Observation and measurement activities**
- **Skills activities**
  1. organise what children need to do
  2. organise what to use
  3. encourage children to observe accurately
  4. define what children have to measure
  5. define the beginning and end of the activity
  6. teach children skills of drawing graphs and recording in different ways – lists – pictures - written – etc.
- **Illustrative activities**

designed to teach a particular skill or knowledge to help understand a concept
- **Research activities**

Children use books to discover types of plastics  
Use of a CD-ROM to see parts of the Human Body
- **Surveys**

collection of numerical data e.g. survey of habitats in the school grounds, depth of tyre tread on staff cars
- **Exploration activities**

try it and see
- **Problem solving**

Building a lighthouse or a house in a box and adding lights and switches
- **Investigations**

these should be activities where children use their conceptual knowledge and understanding of concepts alongside evidence and skills to find a solution to a problem or question.

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**Investigations should involve children carrying out a fair test.**

Even at KS1 children have a notion of what is fair even if they do not implement it e. g cars down a ramp.

**The role of the teacher is to translate this information into effective classroom practice.**

**To summarise, the constructivist view of Learning emphasises; -**

- 1. Learning outcomes depend not only on the learning environment but also on the knowledge of the learner**
- 2. Learning involves the construction of meanings. Meanings constructed by students from what they see or hear may not be those intended. Construction of a meaning is influenced to a large extent by our existing knowledge.**
- 3. The construction of meaning is a continuous and active process.**
- 4. Meanings once constructed, are evaluated and can be accepted or rejected.**
- 5. Learners have the final responsibility for their learning. (A major issue is thus one of motivation, interest and valuation of learning science. It cannot be expected that all pupils will be passionate for science – but hopefully some of them will.)**
- 6. There are patterns in the types of meanings students' construct due to shared experiences with the physical world and through natural language.**

The key role of the teacher is to translate this information into effective teaching for their students. The teacher's role becomes critical in matching appropriate science to the capability of the child, but also in **knowing where to guide the child next.**

**Some implications for teaching primary science using constructivism as a learning theory.**

- **First gain their interest – justify the value of the intended learning. Be interested yourself!**
- **Give opportunities for students to make their own ideas explicit:**

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- use of students' own language
  - awareness of starting point
  - sharing of ideas
  - clarification of ideas
- **Provide experiences which relate to students prior ideas (start from where the children are – elicitation)**
- *encourage students to extend their knowledge of science phenomena*
  - encourage the differentiation of ideas (e.g. heat – temperature, mass – weight)
  - encourage students to bring together and integrate ideas
  - provide experiences which challenge students' ideas
- **Give opportunities for students to think about experiences:**
- provide opportunities for imaginative thinking
  - encourage reflection on the use of models and theories
  - consider alternative ideas or theories
  - introduce the school science view
- **Give opportunities for students to try out new ideas:**
- allow students to gain confidence in trying out new ideas
  - use a variety of contexts (familiar and new)
  - use a variety of teaching and learning strategies
- **Encourage students to reflect on changes in their ideas**
- **Provide a supportive learning environment:**
- encourage students to put forward their own ideas
  - encourage students to listen to each other
  - avoid always creating the impression that there is only one “right answer” but be aware that some times there may be only one answer.

Constructivism as a theory of learning has been explained. Its interrelationships with other theories briefly touched upon. Links have been drawn to the primary classroom, teaching styles, and organisational procedures Suggestions have also been made as to how a primary teacher can teach their children in a manner that supports constructivist learning.

**So we return in conclusion to the statement made at the start of the discussion.**

### **Constructivism.**

Constructivist learning is based on student's active participation in problem solving and critical thinking. Learning is an active process in which learner's construct new ideas or concepts based upon their current ideas or past knowledge.

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The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. They are constructing their own knowledge by testing ideas and approaches based on their prior knowledge and experience, applying these to a new situation, and integrating the new knowledge gained with pre-existing intellectual constraints.

In constructivist thinking, the context, the beliefs, and the attitudes of the learner also affect learning. Learners are encouraged to invent their own solutions and to try out ideas and hypotheses. They are given the opportunity to build on prior knowledge.

**People learn best when they actively construct their own understanding. Children are aided in constructing meaning in science through involvement with practical activities whether they are four and in a nursery or ten and in a year six class.**

## **Exploration and Investigation - Process Skills**

### **Observation**

What can I see, feel, hear, smell, taste?  
Use magnifiers, feely boxes, listening boxes, guessing games, to encourage different ways of observing.

### **Sorting and Grouping**

How are things the same?  
How are they different?  
How many ways can sort a collection; by texture  
Materials, properties?

### **Raising Questions**

What questions can I ask myself?  
Which would be best for.....?  
What would happen if.....?  
How does it work?  
Can I find out if.....?

### **Pattern seeking**

Does this happen in the same way every time?  
Have they anything in common?  
**I think there is a link between.....**

### **Predicting**

I think this will happen- if.....  
- when.....

### **and Making Hypotheses**

I think this will happen because.....

### **Investigating and Testing**

How can I test my ideas?  
Have I recognised all the variables?  
Is my test fair?  
Do I need to measure?  
What, when and how do I measure?

### **Interpreting**

What have I found out?

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Was it what I expected?

**and Evaluating**

Was my test fair?  
Do I need to repeat my test?  
Does it raise further questions?

**Communicating**

Communicating goes on continually

***Is there a connection between communicating orally and recording in writing?***

**and Recording**

Why am I recording?  
Who is it for?  
How shall I record?

At any time during an activity, a child could be employing several of these skills, some for a short period of time, others, such as observation and communication, almost continuously.  
(G. Guest 2001)

**Harlen W. 1978 Match and Mismatch Oliver and Boyd  
London**

In 1978 Wynne Harlen produced the following List of process skills attitudes. And concepts. This resulted in the debate over process skills. (note Harlen 2000B p16 to 20 reviews in detail some of these process skills)

**Skills.**

1. Curiosity
2. Originality
3. Willingness to co-operate
4. Perseverance
5. Open-mindedness
6. Self-criticism
7. Responsibility
8. Independence
9. Observing
10. Proposing enquiries
11. Problem solving
12. Experimenting
13. investigating
14. Raising questions
15. Exploring
16. Finding patterns in observations
17. Communicating verbally
18. Communicating non verbally
19. Applying Learning
20. Cause and effect

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## Concepts

1. Classification
2. Cause and effect
3. Measurement
4. Weight
5. Length
6. Area
7. Concept of Volume
8. Concept of Force
9. Concept of Energy
10. Concept of Time
11. Interdependence of living things
12. Adaptation of Living things
13. Life cycles

It is useful to compare this list from 1978 with the skills and concepts identified in the National Curriculum 2000 and Foundation Stage 2000.

### **Graham Peacock and Robin Smith argue: -**

These are the characteristic features of many investigations:

- 1. Investigations have a purpose - to find out the answer to a specific question.**
- 2. The investigation will turn the question into a test, which they can carry out.**
- 3. The test is planned so one thing is changed to see the effect(s) it produces.**
- 4. Other things, which might affect the results, are kept the same to make the test fair.**
- 5. The effects are carefully observed and if possible, measured.**
- 6. The observations or measurements are recorded.**
- 7. The results are used to shed light on the original question.**
- 8. The investigation might then be repeated or improved or other questions might be raised.**

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<Discussion of Constructivism> Authored by Gordon Guest, UWE, Bristol accessed from [http://www.ase.org.uk/sci-tutors/professional\\_issues/teaching\\_teaching/misconceptions.php](http://www.ase.org.uk/sci-tutors/professional_issues/teaching_teaching/misconceptions.php) date created Aug 2004 page <22> of <24>

## **Graham Peacock & Robin Smith (1995)**

### **Progression in Primary Science**

#### **Piaget and Science. Schools Council Science 5 to 13. With Objectives in Mind (1972)**

##### **Stage 1. Transition from intuition to concrete operations. Infants generally.**

The characteristics of thought among infant children differ in important respects from those of children over the age of about seven years. Piaget has described infant thought as intuitive; it is closely associated with physical action and is dominated by immediate observation. Generally, the infant is not able to think about or imagine the consequences of an action unless he has actually carried it out nor is he yet likely to draw logical conclusions from his experiences. At this early stage the objectives are those concerned with active exploration of the immediate environment and the development of ability to discuss and communicate effectively: they relate to the kind of activities that are appropriate to these very young children and which form an introduction to ways of exploring and ordering observations.

##### **Concrete operations. Early Stage.**

In this stage, children are developing the ability to manipulate things mentally. At first this ability is limited to objects and materials that can be manipulated concretely, and even then only in a restricted way. The objectives here are concerned with developing these mental operations through exploration of concrete objects and materials – that is to say, objects and materials which, as physical things, have meaning for the child. Since older children, and even adults prefer an introduction to new ideas and problems through concrete example and physical exploration, these objectives are suitable for all children, whatever their age, who are being introduced to certain science activities for the first time.

##### **Stage 2. Concrete operations. Later stages.**

In this stage, a continuation of what Piaget calls the stage of concrete operations; the mental manipulations are becoming more varied and powerful. The developing ability to handle variables – or example, in dealing with multiple classification – means that problems can be solved in more ordered and quantitative ways than was previously possible. The objectives begin to be more specific to the exploration of the scientific aspects of the environment rather than to general experiences, as previously. These objectives are developments of those of stage 1 and depend on them for a foundation. They are those thought of being appropriate for all children who have progressed from Stage 1 and not merely for nine to eleven year olds.

##### **Stage 3. Transition to stage of abstract thinking.**

This is the stage in which, for some children, the ability to think about abstractions is developing. When this development is complete their thought is capable of dealing with the possible and hypothetical, and is not tied to the concrete and to the here and now. It may take place between eleven and thirteen for some able children, for some children it may happen later, and for others it may never occur. The objectives of this stage are ones, which involve development of ability to use hypothetical reasoning and to separate and combine variables in a systematic way. They are appropriate to those who have achieved most of the Stage 2 objectives and who now show signs of ability to manipulate mentally ideas and propositions.

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There are approximately 30 science books in the Macdonald Science 5 to 13 range. In the back of each are several pages (p60 – p66 in With Objectives in Mind). These pages list the various attitudes and skills expected of children at the various stages. There is a clear hierarchy of learning.

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