1

What is Science?

Judith Roden and Hellen Ward

Introduction

This chapter will explore the reasons why science is important for people of all ages and why it is a crucial element of an innovative, cross-curricula primary framework requiring a high profile in the primary school. The chapter will outline the nature of science and the development of scientific ideas. Drawing on recent research into learners' attitudes towards science, the focus will be on how creative science can be developed. Additionally, it will explore the importance of ideas and evidence, starting with learners' ideas and encouraging them to collect and interpret their own data thereby helping them to think and reason for themselves while developing a respect for evidence. It will also explore the value of group work in science, its importance in the development of key learning skills and take a look at the wider social aspects of science as a collaborative activity. These features will be interwoven to demonstrate that it is the development of learner attitudes towards science that impacts on their learning both in the short and long term.

Why Science Is Important

The prosperity of the United Kingdom (UK) since the Industrial Revolution of the nineteenth century arose out of the ideas, inventions and creativity of the artisans, scientists and technologists that facilitated the development of its heavy industrial base. While the creation and design of innovative new products is still of paramount importance, in the UK there has been an almost total move away from the heavy and light engineering and manufacturing base of the past. Instead and increasingly, western developed countries depend highly for their income on service industries including the financial services and on highly specialised manufacturing industry. Typically, the trend now is for the mass manufacture of everyday products to take place in those parts of the world where labour costs are generally cheaper and where there is an enthusiasm for the adoption of western culture and affluence. Globally this has resulted in the rise of countries such as China and India as super-powers and their increasing importance on the world stage.

Today, although the 'dark satanic mills' of the past have been replaced by less obvious ways of wealth acquisition, there has never been such a recognition that science and its allied subjects are of fundamental importance:

> It is vital to our economy and to the country's prosperity that we maintain and develop our science base – we are committed to doing this. We need the right people with the right skills to build a strong science base and we are determined to ensure a good supply of scientists, engineers technologists and mathematicians...we have a responsibility to capture the imagination of young people who will become the scientists, technologists, engineers and mathematicians of the future, and to help them to reach their full potential. (The Science, Technology, Engineering and Mathematics (STEM) Programme Report (2006) Foreword, DfES/DTI).

However, the production of scientists is not the sole reason for the need for the development of science education in schools: 'Science and technology are essential … to our quality of life, and lie at the heart of our history and culture' (Science and Technology Committee, 2002, Introduction, p.1).

In order to meet its responsibilities, an education system must address two major closely linked needs: the needs of the individual and the needs of society. To succeed in the global economy, modern-day developed countries need their education systems to produce well-qualified scientists and technologists who will be the researchers of tomorrow. Simultaneously they must produce well-balanced, well-informed, scientifically literate adults who are adaptable, possessing a range of generic and specific skills, aptitudes and abilities that will enable them to take up the many and varied employment opportunities of today and in the future. Adaptability is important to individuals because they may need to be capable of changing their type of employment, perhaps repeatedly, to meet the challenges of a rapidly changing technological society.

Crucial to the future health of an economy and key to the success of its individuals is for all of its citizens to possess effective communication skills. Science has an important role in this process. At a time when learners spend their time passively, often alone, watching television, listening to music or playing computer games, school science provides the opportunity for discussion and the sharing of ideas so crucial for the development of communication skills. It is imperative, even more so than in the past, that such opportunities are provided at the primary level and developed systematically throughout the education system. Learners need to develop a sound understanding of science and the ability to consider scientific evidence objectively.

Scientific Literacy: the Public Understanding of Science

Historically, in the UK, there has been a gap in the understanding of science by different groups of people. While those interested in science have pursued science related occupations and have become more specialist in the scientific knowledge they hold, the education system has allowed many others to reject science at an early stage. Unfortunately this has had two significant and undesirable outcomes. Firstly, many people, some would argue the vast majority, have rejected science and science-related activities, possibly because of the link with heavy industry. Secondly, scientists themselves have become so specialised in their own knowledge and understanding that a gulf has developed between the two significantly different groups in society.

Typically, there has been a general reluctance for many to 'do' science in the past, especially in 'elite' echelons of society. The education system in the nineteenth century prepared individuals to fit into their sections of the highly stratified class system:

> a functional perspective equated schooling with social status. In the propriety schools of the mid-nineteenth century a hierarchy of practical, commercial, and liberal, educational provision was matched to gradations within society…the middle ranks in society still found educational opportunities too limited…the established public schools…felt their central function was to act as social agencies for transforming upper-class boys into English gentlemen…By the second half of the nineteenth century it was not gentleman, but businessmen, scientists and skilled artisans for whom England had the greatest need (Digby and Searby, 1981, 110–11).

Hence, science was often seen as inferior (ibid p.34) and not recognized as important at any level in education. In particular 'public schools were sluggish in recognizing the need to provide scientific education for their upper-class clientele' (ibid. p.111). Indeed, even some who made their money out of successful industrial enterprise seemed to conspire in the process of devaluing the very skills, knowledge and understanding essential to industrial development in order to improve social standing:

> The wealthy manufacturer sends his son to classical school to learn Latin and Greek as a preparation for cloth manufacturing, calico printing, engineering or coal mining…After his scholastic career he enters his father's factory absolutely untrained (Roderick and Stephens, 1981, pp. 238–9).

This scenario compounded the status of science among influential groups and some argue caused a downturn then in the national economy in England. Many, in the past and still today, have not recognised that science offers anything to their everyday lives, rejecting science because they consider it too difficult or irrelevant.

Even when science eventually increased in status and was introduced into a few universities, scientists themselves were few in number and formed an elite group. Even as late as 1884, Francis Galton concluded that "an exhaustive list" of scientists in the British Isles "would amount to 300, but not to more"' (Khan and Sokoloff, 2007, 12). Arguably, some would say, they failed to make a significant contribution to the development of the economy at that time:

> Despite the advantages that people from their class backgrounds had at invention, it must be noted that scientists were not all that well represented among the great British inventors until very late in the 19th Century…Instead, the evidence regarding technical knowledge of all kinds comported more with…James Nasmyth's definition of engineering as 'common sense applied to the use of materials (ibid. p.13).

Clearly the gap between scientists and others has a long and complicated history, but it helps to explain why perhaps there has been a traditional gap between these two groups in society. Consequently, in the nineteenth century and as still can be evidenced today, these two groups sometimes fail to share a common vocabulary and find communication difficult.

Today, the above scenario is at best undesirable and at worse potentially disastrous. There is a very close link in a democratic society between the development of government thinking and the level of its citizens' understanding of science. Public opinion can be highly influential in determining government policy. In the early years of the twenty-first century in the United Kingdom there has been a definite move towards the adoption of a 'green' agenda by all the main political parties because of public pressure, when such ideas were restricted to those labelled as 'cranks' and 'liberals' in the 1970s. Change has come about not least through the discussion of related issues in the popular media.

Many modern-day issues, such as a proposed move to increase nuclear power for the production of electricity, or the siting of mobile phone masts or wind turbines, are contentious. Even different groups of scientists themselves may hold differing views on the same issue, for example, many environmentalists argue for alternative forms of energy such as wind farms, while ornithologists argue against them for totally different reasons.

Other issues raise ethical questions, such as the use of stem cells in medicine or the cloning of 'Dolly the Sheep'. However, if government decisions are to be based on evidence rather than on irrational fears and uninformed opinion, the voting population will need an understanding of science to enable them to make informed decisions about these and other important issues related to science in society, for example, genetically modified crops, global warming, etc. Even more important, perhaps, individual 'family' units need to be able to make sense of and understand the evidence relating to medical issues such as vaccinations and the possible links with health and disability, and other life choices related to diet and leisure.

Making sense of the evidence, however, when much of it appears contradictory is far from easy, particularly when it is given a particular slant or 'spin' by politicians or when the presentation of ideas has been sensationalised or if complex issues have been over simplified by the popular media that confusion and bewilderment results.

Administrations, if they are to endure, cannot afford to ignore public opinion, especially if there are economic consequences involved. Resulting from the concern about the effects of global warming linked with climate change, in 2006 the Labour government in England commissioned a very lengthy, independent review to critically examine the scientific and economic evidence for the theoretical impact of climate change around the world. The Stern Review Report on the Economics of Climate Change adopted a questioning stance and provided an in-depth examination of a considerable amount of evidence from different types of research from around the world. The review makes for interesting reading, particularly in its predictions for the movement of man and other animals as they adapt to the changes in local temperature as global warming takes effect over the world. The report concludes that the effects of climate change, arising from global warming are a direct result of man's impact on the global environment. The review is persuasive; it could be argued that Stern adopted a pessimistic stance towards the available evidence that was mainly drawn from theoretical models (Tol, 2006; Mendelsohn, 2006). Others have argued strongly that, while there are issues that need to be addressed within our society, global change and climate change are merely part of an inevitable pattern of climate change that has little to do with man's activities. Indeed, existing fossil records testify to the fact that significant and influential temperature variations on a global scale over time have occurred without man's influence. Although Stern briefly mentions that global climate change has occurred naturally in the past, the review emphasises the effects of CO_2 emissions resulting from man's activities today.

Regardless of whether man's activities are accelerating climate change and whether man can reverse those changes, there are environmental issues needing to be addressed as a matter of urgency, for example there is a need to curb the long historic practice of burying waste, particularly in our 'throw-away' society in the UK.

Many young people are concerned about the future of the planet and have been quick to adopt recycling practices. However, they may well be ignorant of the finer details of the issues for which they show enthusiastic support; some initiatives related to the environment may well be storing up problems for the future. One example here relates to the trend towards replacing traditional domestic light bulbs with a 'long-life' variety. Few stop to ask about the risks and hazards associated with this practice, yet there will be a need to deal with the disposal of the spent bulbs and the mercury that they contain at some point in the near future. The recycling of rubbish may also be questioned. There is a cost here, not often explored in terms of energy required for the collection of recycled rubbish, particularly if additional car journeys are made to take the rubbish to waste disposal points – especially in rural areas. The trend towards banning the sale of plastic carrier bags or charging highly for them may also yield unexpected consequences: people may drive to the supermarket and back rather than walking. Such problems are typical of those that our learners will need to consider and make informed decisions about in the future.

The Four Threads of Science

Historically, science has had two aspects: first, a body of knowledge and, second, a way of working. The two aspects are totally and inextricably linked. Whenever scientists work, they find out about the world using aspects of scientific method. Similarly, pre-school and older learners find out about the world using the same basic methods. Although the level of sophistication of the tasks will be different and the tools used also different, basically both scientists and learners find out about the world using the same processes. For many years, in theory, if not always in popular practice, one of the principal aims of science education has been to develop learners' understanding through the use of scientific approaches.

Being scientific also involves the development of concepts like electricity or change or movement, etc. There is a strong relationship between learners' use of scientific method and the development of scientific understanding. Furthermore, developments in both aspects of science are strongly influenced by, and rely upon, scientists' and learners' attitudes towards science. The attitudes involved in 'being scientific' generally include curiosity, respect for evidence, willingness to tolerate uncertainty, creativity and inventiveness, open-mindedness, critical reflection, co-operation with others, sensitivity to living and non-living things and perseverance. Although Johnson 2005 sees scientific development as a 'triple helix' with three threads, conceptual understanding, skills and attitudes all developing together to support later understanding, a further area is important in joining the strands together: this is the area of scientific procedures.

Scientific procedures are different from skills and include the nature of science, the collection and consideration of evidence and the development of scientific ideas. Procedural understanding develops learners' understanding of the scientific approach to enquiry, so that they use these ideas in a scientific way.

These four threads are linked and are vital if science is to continue to have any relevance for learners in the twenty-first century. Without this breadth, science is a dry and limiting subject which fails to interest and excite, and where the past trials and successes are reduced to a list of facts to be learnt and experiments to be conducted.

The Importance of Science in the Primary School

Recent change in science at secondary level has reflected a recognition that significant change in practice was needed to ensure that future citizens become scientifically literate. Since May 2006 Key Stage 4 courses in science have emphasised the notion of 'how science works'. The change has come about because of a long-held belief that the science curriculum was overloaded with 'facts to be learnt'. Since 2007 science at Key Stage 3 has become focused around key concepts, key processes, range and content and curriculum opportunities. The content statements have been reduced to four areas of science with life processes becoming part of organism behaviour and health. There has been no change in the programme of study at Key Stages 1 and 2 since 2000 and the last real change occurred in 1995. As a result the primary curriculum is becoming out of step with science in other areas of education and science in real life. Science is a core subject in the national curriculum that contributes to the acquisition of key skills, including thinking skills (Harlen, 2000a; 2000b).

The debate about what the emphasis of science should be has raged for many years. Science did not become accepted at school level until the late nineteenth century (Lawson and Silver, 1973, p.345). Even then, there was disagreement about what school science should consist of Professor Henry E. Armstrong campaigned for a more 'enlightened' approach. He attacked (ibid. pp.345–6) existing teaching methods and advocated 'heuristic' or 'discovery' methods stating that 'boys and girls in the future must not be confined to desk studies: they must not only learn a good deal *about* things, they must also be taught how to *do* things…so that children from the outset may learn to acquire knowledge by their own efforts' (ibid. p.346). More recently, set in a context when teacher educators were trying to encourage primary teachers to include science in their classroom, Harlen (1978) questioned whether content mattered in primary science. Over a decade later, the launch of the Science National Curriculum at Key Stages 1 and 2 in 1989 saw the swing to the practice of a content-driven curriculum: even if this had not been the intention of the writers of what were to become the first statutory orders. Almost 20 years later the debate rages on.

Even with an increasing move towards a cross-curricular approach it is important that science features clearly and has an recognisable, discrete identity if learners are not to receive a diet of science lacking in depth and relevance. This fact has been understood for some time, however it would be unfortunate if this understanding was now lost.

> The field of science is so wide that what is done in school can jump form one facet of the subject to another with out much sense of cohesion developing… even when a topic for enquiry has been selected, the ramifications to which it can lead need to be kept under control, if a sense of definite accomplishment is to result (Ministry of Education, 1963, p.143)

According to the National Curriculum (DfEE, 1999), science is about stimulating and exciting children's curiosity about the world around them: 'Science is an integral part of modern culture. It stretches the imagination and creativity of young people. Its challenges are quite enormous' (DfEE, 1999, p.78). Given this view, it is not surprising that the development of aspects of scientific skills can be identified in the Early Years Foundation Stage (DfES, 2003a) in the Curriculum Guidance for the Foundation Stage, within the aspect of 'Knowledge and Understanding of the World'. It is also promoted in both Key Stages 1 and 2 of the English National Curriculum. The Qualification and Curriculum Authority (QCA) (2000, p.32) states that in order for children in the Foundation Stage to successfully develop their knowledge and understanding of the world, teachers need to provide: 'Activities based on first-hand experiences that encourage exploration, observation, problem solving, prediction, critical thinking, decision making and discussion' (QCA, 2000, p.82) – a real challenge for the early years practitioner and indeed all teachers and others who work in the classroom with learners of all ages!

Attitudes for learning science are also important and need consideration and development. Attitudes do not feature explicitly in the science National Curriculum 2000, however, they are important and, when considering a child's education holistically, cannot be ignored. Worryingly there seems to be a trend for learners to turn away from science as they get older, linked to the way that science concepts are revisited in preparation for National Tests at Key Stage 2.

Overall, the development of understanding of science is dependent on all these aspects. Teachers need to weave a carpet of provision of science for primary-aged children where knowledge and understanding develop alongside scientific procedures, skills and attitudes towards and in science.

Learners' Attitudes towards Science

Research into learners' attitudes towards science reveals that they are formed at an early age. Therefore, it is crucial to capture this natural interest in science and to capitalise upon learners' experiences of finding out about the world through exploration. The aim of school science is to extend these opportunities, rather than to limit the curriculum, as seems to be the case today in some schools. The Acclaim Project (www.acclaimscientists.org.uk) interviewed eminent scientists engaged in current research and development in science. One of the most interesting findings related to the age at which scientists had first become interested in science. Typical responses included:

> 'I don't remember when I was not interested in science.'
> 'I was interested in science from a very young age, perhaps 5 or 6.'

While female scientists seemed to suggest they were older when their interest in science began, a common factor identified for all was the exposure to other people who had a passion for things scientific, such as a parent, relative or friend. Significantly, teachers and 'hands-on' experiences were both identified as factors that played an influential role in developing the scientists' interest in science. This concurs with views regularly expressed by practising and intending teachers whose own experiences in school science, both positive and negative, impact significantly on their long-term attitudes towards the subject.

Clearly, then, it is important for science to feature regularly throughout the primary years. However, it is important not only that it is included, but that it is of the right quality. Her Majesty's Inspectorate (HMI) subject report for Primary Science (Ofsted/HMI, 2003) found that there had been a reduction in the time given to science and, particularly, for investigative work.

Other research suggests that many learners have poor attitudes towards learning in science at the primary level. Pollard and Triggs (2000) found that as the learners in the sample grew older, science became one of three subjects least liked in the primary curriculum and that, by Year 5 and Year 6, learners rarely nominated science as the subject most liked, favouring art and physical education instead. Learners said they found science difficult and disliked both the amount of writing they had to do and the weight of information they had to learn. Girls consistently disliked science more than boys until Year 6 when antipathy was much more evenly divided between the sexes. Also the findings suggested that as primary learners grew older, their awareness of learning processes in science declined rather than grew. For example, there was a decline in their awareness of science as an investigative activity because of the tightly framed subject-based and teacher-controlled curriculum (Pollard and Triggs, 2000, pp.87–98).

Learners need to be provided with both the opportunity and the time to engage with the processes and the procedures of sciences in order to develop sound knowledge and understanding, and to develop more positive attitudes as a result.

The Importance of Group Work

Unlike many subjects of the primary curriculum, science provides the opportunity for working as a group rather than working independently within a group situation. Science enables learners to be involved in group work where they have the opportunity to share ideas, refine vocabulary and co-operate with each other in collaborative practical activities. Research shows that learners who work together learn more than when working alone. This is true of scientific activity at any level, as sharing ideas and group work are fundamental to external scrutiny, leading to the progression of ideas.

The use of the information super highway has revolutionised both the speed of communication and the ability of scientists to collaborate with each other and to share and develop ideas sometimes across continents: merely sharing ideas is insufficient. When asked what qualities were needed to solve a scientific problem, an eminent scientist replied:

> The ability to ask the right question is very important…perseverance and determination … Lateral thinking is useful when a straightforward solution to the problem is not obvious. The ability to admit that the scientific evidence shows that your pet idea is wrong and someone else's idea is right is also important. Today, much science is done in teams, so the ability to work in a team is helpful. (www.acclaimscientists.org.uk)

The above qualities are not exclusive to science and scientists and, therefore, the development of these qualities should be at the heart of education. The ability to work as part of a group is needed if learners' procedural understanding and scientific attitudes are to be developed. Practical science provides many opportunities not only for the sharing and challenging of ideas amongst peers, but also for the development of group skills.

The role of the teacher is crucial in this process: 'neglect of the process skills means that learners have to take ideas as given by teacher or text book and there is a great deal of experience that shows that this is unlikely to lead to understanding' (Sherrington, 1998, p.28). If the teacher always plans the investigation, providing opportunities **only** for illustrative activities, i.e. those that illustrate a concept or scientific principle, the skill of planning will be lost. Similarly, if learners are never challenged to interpret their own collected data, to explain what the data tells them and evaluate their own procedures, they may never develop the higher-level skills associated with scientific enquiry.

Starting with the learners' own ideas is important, as they need to develop their ideas progressively in a variety of topics throughout their primary years. Learners need to be encouraged to ask their own questions and find the answers using a wide range of approaches and, in doing so, to collect evidence. Approaching collected data with an open mind, trying to make sense of any developing patterns and drawing conclusions are activities that develop respect for evidence. Collaborative group work introduces learners to the social aspects of science as well as providing opportunities for the development of key learning skills. All these features are interwoven and support the development of learners' attitudes towards science, which have a major impact on learning.

The Nature of Scientific Ideas

The range of accepted scientific knowledge and understanding is immense and has been developed over thousands of years. The body of known science knowledge, however, is not static and unchanging. The process of change happens gradually: many original ideas have been challenged over time, for example, the ideas that the earth is the centre of the universe and is flat. Other ideas have been refined over time, for example, the idea that the smallest parts of an atom are neutrons, electrons and protons. However, most of the ideas in science that are accepted as true today have one thing in common: although the ideas are not accepted absolutely, there is some evidence to support them. Although there is a commonly held idea that scientists set out to 'prove' their ideas, in reality, scientists set out to 'disprove' their ideas. An idea is adopted because conclusions have been drawn and have been communicated to others, which has resulted in the idea being challenged and either rejected or accepted. No matter how much evidence there is to support a theory, it only takes one repeated finding to disprove an idea. Sometimes change occurs through a process of a scientific revolution when accepted ideas are looked at in a new and novel way – when a scientist steps outside existing paradigms and takes a creative look at accepted ideas, this can lead to giant leaps in scientific understanding (Khun, 1962).

Learners need to develop an understanding of the ways in which previously accepted scientific facts have changed over time if they are really to appreciate the essential essence of science. This aspect of science should be explicitly included in the teaching and learning approaches used in the primary school, which should include some reference to science in the past. If not, science merely becomes a body of knowledge that has to be learnt, with no opportunities for 'new' discoveries or a creative response on behalf of the learners. The focus on *what* is known, rather than *how* it is known, makes science sterile. Evaluating evidence is important in science and is also an important generic life skill. Open-mindedness and respect for evidence are important attitudes in science and important also in everyday life, i.e. making decisions based upon evidence rather than jumping to conclusions.

Enabling learners to make the link between their ideas and the evidence for them can be encouraged through simple activities. A good activity to make

Figure 1.1 What ideas are generated by this picture?

explicit the need to look objectively and to respect evidence to support conclusions follows, starting with Figure 1.1.

Many ancient sets of footprints have been found and these have facinated scientists for decades. Learners can be asked to reveal the ideas they hold as a result of looking at the picture above. When shown this drawing recently, some learners stated that they thought the drawings were of footprints. When asked why they thought this, it was clear that they had brought evidence from everyday life to their interpretation of the drawing, for example having seen birds' footprints in the snow. They also stated that one animal was bigger than the other, as evidenced by the size of the footprint, and that the animal with larger prints had claws. While the smaller animal moved with both feet together, the larger footprints were made one at a time. An adult learner suggested that the small footprints were made by an animal with a small brain who had not evolved a brain big enough to have co-ordinated movement.

When more evidence (Figure 1.2) was presented, the learners put forward ideas of a meeting between the two animals, resulting in the smaller animal flying away, having a piggyback or coming to a 'sticky end'. The evidence that supported these ideas was elicited and questions were asked which focused the learners on what evidence explicitly supported their ideas and whether all ideas could be correct. In this case all ideas had merit, although learners developed their 'pet idea', but it was not possible to discount the other views. In fact, there was no evidence to suggest that both footprints were made at the same time! Once the learners realised that in this type of science lesson the expectation was for them to promote ideas, to discuss evidence and that

Figure 1.2 More evidence is provided; have the ideas changed?

their responses could be modified as more evidence came to light, they were ready and willing to use their enthusiasm and creativity in other activities. Challenging learners to use their ideas and collect evidence can occur in most activities, but it requires changes to the way that science is delivered in some primary classrooms.

Tracks in everyday modern life provide as many challenges as using examples from pre-history. The tracks in Figure 1.3 were made on a beach in the USA in 2004. Looking at the different tracks should provide some evidence as to the 'animals' that made them. Enabling learners to be creative just requires less teacher direction and an understanding that science can be meaningful. Making tracks at school to solve problems and include forensic science into classroom is discussed in chapters.

On another occasion, everyday materials were used to link science to real life. Learners were asked to apply this approach to an everyday setting situation. A range of cans of proprietary soft drinks, i.e. a 'Coke', a 'diet Coke' and a 'Seven-up' and a tank of water were used to challenge learners to provide ideas of what would happen when the cans were placed in water. Learners used previous knowledge of floating and sinking to arrive at suggestions. These included 'Diet Coke will float as it is lighter' and 'They will all sink because

Figure 1.3 What made these tracks?

they are heavy'. The cans were placed into the water one by one, with an opportunity for the learners to observe what happened to each can, and learners were asked if they would like to alter their ideas based on the new evidence. In the event, the 'Seven-up' sank, the 'Coke' floated just off the bottom and the 'diet Coke' floated just below the surface, which resulted in amazement and quick suggestions as to why this might be. The learners then had to think of ways to test out their ideas.

Suggested tests included weighing the cans, measuring the liquid, counting the number of bubbles in set amounts of each liquid and the use of secondary sources to research the composition of each liquid (for example, amount of sugar). One child suggested that if the cans had been placed in the tank in a different order a different result would have occurred! Identifying learners who require support or challenge is an additional advantage of working in this way. Although no writing was involved in the original part of the session, this did not make this activity less valuable. When the learners tried out their tests they recorded their results and communicated their findings in poster form later in the week.

Simple Starting Points for Interesting and Creative Activities

Initially, when asked to use a simple object as a starting point for creative science activities, practising teachers and students in training often state that they find this difficult and scary. However, when challenged to do so, they often provide a wealth of ideas for sharing with colleagues: 'At first I was really worried, I didn't know what I could choose, but when you think carefully, look in books and so on, it is so simple, isn't it!' (PGCE student, 2004).

Creative and interesting activities can be developed from many different, but simple starting points. Table 1.1 provides some suggestions for creative practical activities from starting points where the initial focus is on play, exploration and observation. Many of the activities can be approached at different key stages, but need to be tailored to meet the known needs of individuals and groups of learners in the classroom. Teachers and other adults can start by presenting the object to the child, stepping back to observe what learners notice, how they interact with the object(s) and noting what questions are asked. Differentiation is by outcome, as initially the learners will approach each task with differing levels of skills and experience. It is found that younger learners will approach objects in a different way to older learners, with their approach based on trial and error. The expectation of older learners is that they will apply a more systematic, logical approach to the activities, although this depends upon previous experiences and opportunities to work independently.

Table 1.1 Creative Practical activities

Resource	**Creative practical activities**
	Guess what the object is?
Digital camera close-up photographs of various object objects, e.g. pineapple	Observational drawings of small parts of the looking for detail. Learners take close-up photographs and challenge others to identify them.
Eyes	Looking at each other's eyes. Noticing the different colours of eyes. Recording their friend's eyes using wool stuck on card. Covering eyes and observe change in learners.
Baby teeth Toothbrush Toothpaste	Looking at different shapes of teeth and their function. Mixing toothpastes with water and observing how much foam occurs and whether all the toothpaste dissolves.
Looking at different animal bones	What animal did it come from? How do you know? What ways are they the same? What are the differences? Which bone might have been a mouse and which an elephant? Close observation using digital microscope.
Woolly jumper	Close observation of wool. Looking at where the wool comes from and how it is treated to become the jumper. Wool under the digital microscope.

Resource	Creative practical activities
Archimedes thermometer	Watching the liquid filled bulbs rise and fall with temperature. Exploring how other water filled things float and sink. Cartesian divers.
Sponges	Observation, what is it made from? Man-made and natural sponges. How much water does it absorb? Will it float or sink? How many holes are there and is there a pattern between holes and sinking/water absorbency?
Ice cube	How can you keep an ice cube in the classroom for the longest time? What could be designed? Create an ice-cube holder.
Sand and yoghurt pots in a tray or sand tray	What proportion of sand and water do you need to make a good sandcastle?
Poppy seed heads	Seed dispersal. Thinking about what it might look like inside. What colour and size might the seeds be?
Seed packets: a variety of types need to be observed and discussed	Look at the picture of the plants on the seed packet. How big do learners think the seed will be and why do they think this? What colour do they think they will be? Young learners often think that tall plants will have big seeds and will be the same colour as the resulting plant. Opening the seed-packet is often very exciting for very young learners and can lead to questions to test, whether the biggest seed produces the biggest plant. This can lead immediately to further investigation to extend learners' experience of seed and plant beyond cress. (Δ Ensure seeds are not treated with pesticides.)
Hole-punch	How does it work? What does the spring do? Link to forces. Looking at other springs, e.g. pogo sticks. Helps learners make connections.
Deflated balloon, ice balloon, water balloon, air balloon	Initial observation of the 4 balloons will lead to noticing differences and similarities between them. Learners can be asked to describe each of the balloons and the vocabulary used noted. Younger learners can

(Continued)

Table 1.1 (Continued)

Resource	Creative practical activities
	have their observations scribed for them. What learners notice about the balloons could lead to many questions. Learners can be asked to raise questions. Questions raised can then be 'scanned' by the teacher for productive questions and these can lead to specific activities, e.g. What happened when they are put in water? Will each balloon bounce? How high will it bounce? How high will it bounce on different surfaces? What is the weight of the balloons? Here younger learners can compare weights, older learners can use instruments to measure.
Bubbles	Bubbles provide an excellent starting point for many observations. Vocabulary can be noted, observations can be shared and, if necessary, revisited. Different sizes and shapes of wands can be used to find out whether the shape of the wand affects the shape of the bubbles.
Tea bags	Looking at the similarities and differences between tea bags. Close examination of different bags under a hand lens and digital microscope to find out the size of the holes. Weighing the tea in different bags. Looking at the shape of the tea leaves under a digital microscope. Making tea at not more than 60 degrees Celsius. Looking at the colour of different teas. Which tea bag makes the strongest tea in five minutes? What happens when you soak fabrics in the tea?
Soap	Which soap washes paint off quickest? Warm and cold water can also be tested. How long before feet go wrinkly? Placing feet in warm water and seeing how long before they wrinkle. Drawing feet after. How much lather does a bar make? Testing different types of soap, turning the bar in hands once and then rubbing them together and comparing amounts of lather.

Summary

This chapter has considered a number of important points related to science, the nature of science and the approach of science in the primary curriculum. It has shown that science knowledge and understanding has to be provided for alongside the development of procedural understanding and process skills; that for the future well-being of the individual and society learners' attitudes towards and in science must not be ignored.

There is a need to move away from the view that promotes science as a stuffy subject full of facts to be learned. This view needs to be replaced with an approach to teaching that envisions science and the teaching of science as a creative activity. If this is to be successful, then teachers need to give full consideration to learners' ideas and to utilise these to further learners' understanding of science in everyday life. The challenge for today's primary teacher is to break from the traditional mould and to teach science in a creative way making it more relevant to the future generation of 'could be' scientists.

Further Reading

Harlen, W. (2006) 'The goals of science education', Teaching Learning and Assessing Science 5–12 London: Sage.

Hamblin, A.H. Foster, J.R. (2000) Ancient Animal footprints and Traces in the Grandstaircase-Escalaute National manument, South Central Utah. Geological Association Publication 28 can be downloaded from www.utahgeology.org/pub28_pdf_rules/Hambin.pdf.

Osborne, J.F., Duschl, R. et al (2002) *Breaking the Mould: Teaching Science for Public Understanding*. London: Nuffield Foundation.

Osborne, J. F., Ratcliffe, M., Collins, S., Millar, R. and Duschl, R. (2003) 'What "ideas-about-science" should be taught in school science?' A Delphi Study of the 'Expert' Community. *Journal of Research in Science Teaching*, 40(7): 692–720.