Reflections on and analysis of the use of drama techniques and dialogic practices in teaching science in primary school

● Clarysly Deller

Abstract

This reflective article examines science learning, experienced in a primary school, in light of theories of social constructivism and how they can illuminate and explain learning experienced within an innovative project. This project sought to combine the use of drama techniques to teach tricky concepts in science with discussion, collaboration and peer support. Having established the background to the project, this article examines some of the theories of social constructivism evidenced in the project. Its purpose is to reflect upon learning so as to usefully promote similar approaches in the future. Its findings point to the usefulness of social collaboration in learning, the value of dialogic practices and the use of scaffolding to enhance and deepen understanding.

Introduction

Effective primary science education should support children to change their ideas and forge new learning in order to produce a better understanding of the world around them (Skamp & Preston, 2015). From 2010 to 2016, I was involved in a Primary Science Teaching Trust (PSTT)-funded project using drama techniques to deliver aspects of the primary science curriculum, with researchers from Oxford Brookes University and Staffordshire Entrust. Although using drama is not a new concept (Littledyke, 2004; Precious & McGregor, 2014), the project promoted diverse opportunities for children to engage directly with scientific processes and concepts. They worked collaboratively with peers, developed argumentation and discussion skills, and the project promoted curiosity, creativity and inclusion (McGregor & Precious, 2015). It led the children to connect what they learned in science with their experiences in life, promoting ownership of their learning. The researchers argued that *'Drama can support constructivist learning because the children become active agents of their own learning'* (McGregor & Precious, 2015, p.23).

Talk and discussion was a major part of this process, helping the children to be more aware of the benefits of dialogic talk in their learning to aid problem-solving and to develop their science understanding (Mercer, Dawes & Staarman, 2009; Alexander, 2010). This article represents my reflections on the learning experienced in the school, using social-constructivist learning theory to shed light on the outcomes I observed. I found that many of the activities spawned deep learning involving discussion, exploration and modelling, which enabled the young learners to understand new concepts, and develop their own scientific understanding.

Background

An old-fashioned and clichéd model of teaching, where an instructor relays knowledge to a fairly passive student, has changed over the last 20 years. The introduction of the National Curriculum in 1988 and its subsequent reviews have promoted a much more dynamic and child-centred curriculum. The 2013 curriculum review introduced 'Working Scientifically' as a major part of the science curriculum, which has further promoted child-led learning and practical investigations as integral to a child's education in primary schools (Department for Education, 2013). Reports such as the Wellcome Trust's recommendations for reviving primary science (The Wellcome Trust, 2014), alongside Ofsted reports on maintaining curiosity, may have been influential in effecting this change (Ofsted, 2013). Employing techniques that involve children in active science learning, which are transferrable across the curriculum, are therefore useful (McCallum, Hargreaves & Gipps, 2000). Mastery in the new curriculum, which involves consolidation, practice and discussion of an idea by reviewing and revisiting learning, is encouraged (Department for Education, 2013). Practices that allow for the testing of ideas and promote the assimilation of previous knowledge are key in promoting mastery, as are active experiences that facilitate and enhance learning (Archer *et al*, 2015). Conceptual understanding must be an integral part of the learning (Skamp & Preston, 2015). I will reflect on how children's social interactions also facilitated deeper learning; the dramatic activities used within the science project were rich in social interactions.

Methodology

Learning in the context of using drama activities is by and large a social learning experience, with children working collaboratively and coming up with ideas and theories expressed in new and different ways. I have oriented this paper around learning theories to illuminate and help explain the learning experienced. I will reflect upon learning evidenced in light of social constructivist theories, in which connection-building using scaffolds for learning, and dialogue to promote deeper understanding, are key. Dewey's (1859-1952) theories of practical learning through creativity and collaboration; Bruner's (1915-2016) scaffolding of learning to enhance development; and Vygotsky's (1896-1943) zone of proximal development, where the potential for learning beyond the child's usual means is facilitated via knowledgeable others, will be used to help understand the learning. Bruner's ideas of allowing children to construct ideas and knowledge through doing – learning being a process of discovery – are also important. The drama activities incorporated in the children's learning allowed all the facets of their learning to be polished and showcased, and led to enjoyment, enthusiasm and deeper learning.

By using reflection to examine the teaching and learning experienced within the Dramatic Science project, I am aiming to engage in continuous professional learning. It has enabled me to recognise and examine assumptions and patterns of learning behaviour in the children, allowing exploration of their learning. The process has enabled me to become more aware of how children learn, the links to social learning theory and the importance of dialogue and peer interaction in meaning-making.

Analysis and discussion

This project included thinking, discussion and reflection at its core. New units would often be introduced with a dramatisation of a monologue, based on a scientist relevant to the field of study. Example monologues can be accessed in *Dramatic Science* (McGregor & Precious, 2015). Having listened to a dramatic monologue about a leading scientist in the field who the children were studying, they worked together at the start of a topic to create a tableau (Figure 1). This allowed them to demonstrate their thoughts and ideas about how the scientist may have worked. It would seem that the discussion about a scientist's qualities and collaboration in working scientifically inspired children to fully engage in the activities. It helped them to understand that scientists are real people like us, and have struggles to go through in order to attain their goals. Children expressed that it made them feel that *'I know that I can be the scientist that I want to be'* ('Clare', 2017).

Dewey (1938) argued that learning should be based on inquiry, where pupils experience real life, practical workshops in which they can demonstrate their knowledge through creativity and collaboration (Jennings, Surgenor & McMahon, 2013).

Figure 1: Children forming a tableau demonstrating the qualities of a scientist.

Figure 2: Modelling cotton growing with counters representing nutrients in the soil.

After the dramatic monologue starter, children would then move on to practical investigations based on real life examples. Dewey stated that practical work gave '*…the student a better hold upon the educational significance of the subject-matter he is acquiring'* (Dewey, 1904, p.2). He advocated that pupils should be provided with opportunities to think for themselves and articulate their thoughts, working in depth on any topic. The experiences of learners in the dramatic science project adhered to this principle.

For example, while studying a plants topic, the work of George Washington-Carver (Biography, 2018) was explored via dramatic monologue before thematic work undertaken. Having learned about the decreasing yield for the cotton farmers over time, the children then modelled cotton seeds growing, employing counters on the floor to represent nitrogen in the soil (Figure 2).

Each child became a 'seed' and, as it grew, a counter was picked up. Once there were no more counters, the new seeds ceased to have the nutrients to grow healthily. They then modelled peanuts growing, fixing new nitrogen in the soil by replacing counters. This enabled the children to conceptualise how certain plants deplete the soil's vitality, while others can replace minerals. They then discussed and modelled how crop rotation serves to replenish the soil's fertility.

This discussion then led the children to examine the school's surrounding farmland. Some had noticed that different crops were grown on the field beside the school each year. This discussion led to the children suggesting that they try growing the same plant in the same soil repeatedly, to see what happened (Figure 3). Radishes were chosen, as they crop quickly. After several rounds in the same soil, the children saw how the radishes were poorer in size. This led them to develop a crop rotation plan for the school garden. Further practical inquiry was used as the children went on to explore different ideas for uses of a plant, in the same way that George Washington-Carver had come up with over 150 ways of using the peanut.

They practically tried and tested product design for their ideas, linking to design and technology objectives, and used discussion to link their everyday ideas towards a more scientific viewpoint

Figure 3: Growing repeated crops in same soil.

Figure 4: Modelling seed germination.

(Mercer *et al*, 2009). Other cross-curricular links were drawn, linking to Black History Month and employing their science learning in their creative writing. This practical exploration of the theory and practice of a famous scientist led the children to develop individual learning ideas gained from hands-on work and drama exploration (Claussen & Osborne, 2013). Experiential learning afforded the children the ability to imagine themselves as real scientists, such as George Washington-Carver (Fisher, 1998). They were able to articulate their learning, linking the theories of how plants grow and develop to practical applications, such as the crop rotation plan for the school garden, broadening the scope of their learning and framing their learning experiences. Indeed their shared discussion deepened their understanding (Turner *et al*, 2012) and provoked a desire to care for the soil and the local environment, leading many to join the school's Eco Club and take an active interest in caring for their local environment.

The drama project used the spiral nature of the National Curriculum, where topics are revisited at a deeper level as the children mature, to its advantage. Prior knowledge and previously-remembered learning were examined, helping children to remember, revisit, rebuild and construct new knowledge. Bruner (1915–2016) held that all things can be taught to children and proposed that children should revisit the same ideas as they mature, presenting knowledge appropriate to the age of the learner (Wall, 2012). He advocated that children should be involved in teaching activities that enable them to explore and develop their own knowledge, based on prior learning (Bruner, 1974). As an advocate of Piagetian thinking, he initially described stages to learning, citing 'tabula rasa' based on Aristotle's idea that learning is gained by experience as a starting point, although he came to believe more in the social, cultural and historical influences on learning and that the learner *'rather than being a creature of experience, selects that which [he] is to enter'* (Bruner, 1985 p.6).

In the drama project, children's prior knowledge about a topic was often assessed by children enacting prior understanding using their bodies. For example, in a plants topic, children may have been asked to model how a seed germinates, allowing identification of misconceivers and correct conceivers (Allen, 2014).

In this example (Figure 4), the child has not modelled that a root is the first part to appear, after the seed swells. There is cognitive dissonance in the construction of his idea. During the session, when he has seen what others are doing, and explored and observed practically how seeds germinate, looking at cress seeds planted on consecutive days using a Digi-scope, he revised his ideas and adapted them, so developing a new understanding. For the teacher this was a useful tool, as his ideas could be clearly seen.

This helped in planning subsequent teaching to effectively address alternate conceptions identified (McGregor *et al*, 2017). Mansour and Wegerif (2013) proposed that children need a place in their lessons where they can discuss and listen to a range of often tentative views so as to develop their learning. These ideas that have previously been held as truth, or used to make sense of the world, are challenged via drama and discussion, leading children to re-form their thinking (Driver, 1988). Revisiting a modelling activity such as this, after the children had had further learning and exploration on the topic, enabled the teachers to see whether the child had changed his/her ideas and developed new learning. Learning experiences that incorporate multiple perspectives and involve reflection lead to effective knowledge acquisition (Mansour & Wegerif, 2013, p.81) and the drama activities facilitated this.

Excitement and curiosity were evident in the learners during sessions using drama activities. Bruner advocated goal-directed learning driven by curiosity and held that social interaction lies at the heart of good, effective learning (Jennings *et al*, 2013). Curiosity in learning is also set out in the National Curriculum (Department for Education, 2013, p.144), which urges that *'pupils should be encouraged to recognise the power of rational explanation and develop a sense of excitement and curiosity'*, advocating that children's learning be curiosity-led. Ofsted (2013, p.4) stated that *'the best science teachers… set out to "first maintain curiosity" in their pupils'.*

Bruner's later work expanded on the idea that knowledge is socially constructed. Within the project, we found that the social and collaborative aspect of the learning enhanced the children's curiosity and inquiry skills. They were able to incorporate discussion and co-operation in their learning, thence producing new ways to solve problems. This discussion was dialogic in nature, with reciprocal interchanges between pupils. The dialogic repertoire of the children was expanded, as they delved into interrogatory and exploratory talk alongside their learning talk (Alexander, 2010). For example, in designing a method of windborne seed disposal for a 'paper-clip' tree, the children first watched clips of seeds being dispersed, explored some different seed carriers themselves, and then modelled with their bodies how seeds might travel. They subsequently designed their own seed carrier together. They were able to refine and improve designs via discussion and interaction, looking at others' methods and making prototypes to try (Figure 5).

This type of activity helped the children to develop reasoning skills, as they discussed and justified their designs collectively. The collaborative nature of their learning seemed to be an effective tool in developing deeper and more critical approaches to problems. Vygotsky (1930) proposed a number of theories that *'emphasised social processes as the means by which all reasoning and understanding arises'* (Jordan *et al*, 2008, p.59). He held that, through interaction with others, knowledge is created and then internalised. Tools such as language and social interaction were seen as vital to the development, creation and assimilation of ideas and learning (Vygotsky, 1962). However, where Dewey and Vygotsky base the development of new thought processes on language, Bruner felt that there is not one single way, thus, by equipping students with a whole menu of learning strategies from which they can choose, successful education is unlocked. Self-motivation and curiosity empower the learning alongside support, courage and risk-taking (Bruner, 1985). Vygotsky emphasised the role of language and culture in cognitive development, where learning is essentially a social phenomenon and children actively construct learning as they interact with others (Wray, 2014). Vygotsky's key idea of the 'zone of proximal development' (1930) led many psychologists to develop the belief that learning can be enhanced by scaffolds to support a depth of learning greater than that achieved without support (Rochford, 2016; Wray, 2014). He advocated that social interaction is the means by which effective reasoning and good understanding is achieved. This 'zone of proximal development' described how providing support helps learners to progress further than if they work in isolation (Vygotsky, 1930). A key strategy in the drama activities was the use

Figure 5: Collaborating to test refined prototype for seed dispersal.

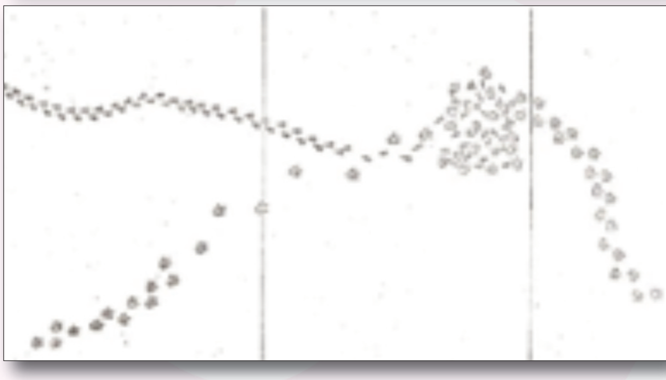
Figure 6: Illustration of fossilised footprints found in a Staffordshire mine.

and support of knowledgeable others accompanied by frequent discussion of their ideas amongst peers. During the drama project, each technique used was examined reflectively.

After some sessions, children were interviewed to ask how the strategy helped them to learn. This enabled analysis of the learning encountered and provided a child's voice on the learning process. For example, some children discussed their learning of how electricity travels in the torch circuit. In the group was a child who had previously taken a torch apart, and had seen the circuit in detail and developed his own ideas as to how it worked. The knowledge of the physical layout of the internal workings of a torch facilitated the group to arrive at a much more accurate model of the process than the other groups who had no 'knowledgeable other'. Another example within a plants topic, where prototype seed carriers were made, used the knowledgeable voice of the Science Governor to help them refine methods of making paper aeroplanes that flew well. These initial ideas were then improved and taken further by the group via collective discussion, leading to a more effective seed carrier than if they had been left to their own devices. This enabled the children's potential for development to be tapped through collective actions, hence building new learning.

Dialogic techniques

The importance of discussion in science learning cannot be underestimated. Many of the activities undertaken in the project helped the children to develop ways of expressing their ideas, a willingness to listen to others, explore differing ideas and adapt their own thinking in the light of shared experiences and new discoveries. They had 'talking science' sessions (Eley, 2003), where listening and open discussion were modelled and practised, so that they could better articulate their knowledge development and learning. This is a method that also explores argument as a teaching and learning strategy for primary science. It required the children to engage with the language of science, but also generate and justify their claims to knowledge (Eley, 2012). An example from the project evidencing this, within a rocks and fossils topic, comprised discussion revolving around an activity that I devised, using the fossilised footprints of two animals (Figure 6). Children were asked to hypothesise what could have been happening, using evidence from the picture to draw their conclusions. One child hypothesised that the larger footprints showed the animal beginning to run. To justify his view, he demonstrated walking and running, illustrating the size of stride for each. The children then used this information to discuss what could be happening and predict what the next set of footprints would show. This was accompanied by



Figures 7 & 8: Photograph and diagram of the full set of footprints uncovered in a Staffordshire mine.

children using clear arguments, with justification and evidence to support their claims. Each group came up with different scenarios, which they could clearly defend.

In this lesson, two further slides were gradually added (Figures 7 & 8), and children asked to re-form and justify their refined views. This further illustrates the dialogic nature of the learning, where Alexander's principles of collective, reciprocal, supportive, cumulative and purposeful learning were evidenced (Alexander, 2010).

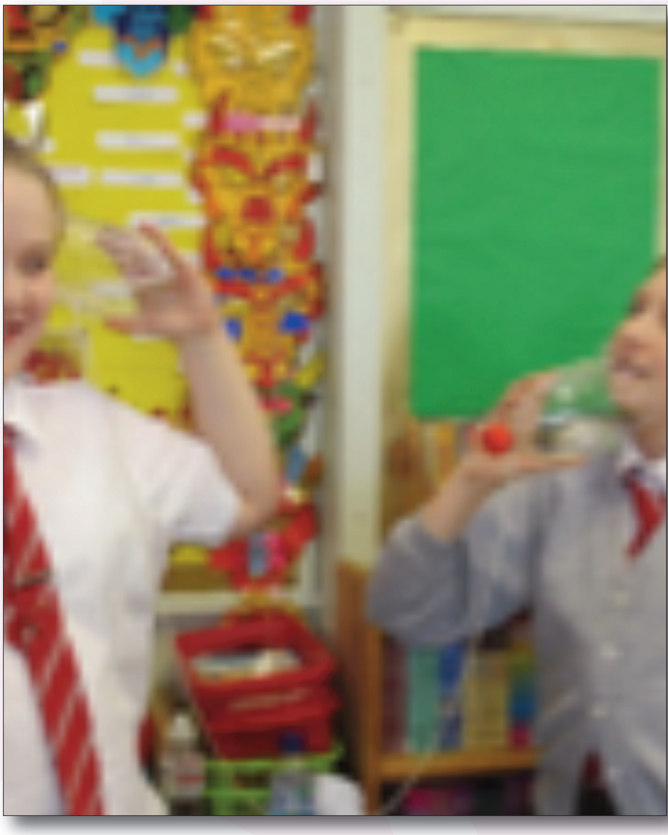
Within the project, an emphasis on discussion and trying out new ideas using drama strategies enabled the children to express their new ideas as they formed, refining and improving on their developing theories. They gravitated towards new groups within the class, as children with similar ideas teamed up. These learning groups, or communities of practice, are a key idea in Wenger's theories (1999). He argued that we are all part of communities of practice when we share and interact in an activity together and with the world around us (Wenger, 1997). The learning community formed by children engaging in scientific drama activities united them and gave them a sense of community as they negotiated new meaning together. For example, when children were investigating burrs, following the work of George de Mestral (Biography, 2018b), they came up with their own models and ideas as to how the burrs cling and grip (Figure 9). Reflecting on this activity, children demonstrated an ability to use past experiences of how things grip and cling, to devise mechanisms that the burrs might use. They built on their own past experiences as well as modelling and discussing possible means by which burrs could cling and release. As groups began to discuss and refine their own ideas, they formed strong bonds with each other, because all the participants felt ownership of their group's shared vision.

Although building on what children currently know is an important idea held by constructivist theorists, effective learning also moves children from where they currently are, addressing misconceptions on the way, arriving at a goal via a child-led path, which deepens both knowledge and understanding (Driver & Oldham, 1986). Ausubel (1918-2008) placed great emphasis on what the learner already knows, with the construction of

Figure 9: Children modelling how they understand Velcro to work, so creating new meaning together.

new concepts and enlarging of held knowledge occurring via shared learning experiences. He also advocated that the learning, dependent upon the individual's knowledge base, be meaningful (Ausubel, 1969). This is where the science project was effective, as each child articulated their own knowledge through drama, which could then be collaboratively altered and consolidated as they learned and shared new ideas together. As illustrated earlier in this article, examples of meaningful learning, with real life application, enlarged the children's knowledge and understanding of the world. When looking at George Washington-Carver's work, his amazing inventiveness and ingenuity spurred the children into inventing many different products from one source – as George had done with the peanut. This real life example helped the children to understand better the diverse work of scientists. They chose an object, for example an onion or a plastic bottle – and had to invent as many ways of upcycling or repurposing this. Paper, dye, food, insect repellent and polishing metal were some of the uses they came up with for an onion.

Figure 10: Using ingenuity to invent new purposes for plastic bottles.



Plastic bottles generated many new products (Figure 10), and forged links with sustainability and using the planet's resources wisely. Where our experiences move away from Ausubel's theory, however, is his lack of stress on practical learning, in which he states that there is an *'unwarranted belief…that discovery learning is invariably meaningful'* (Ausubel, 1977, p.163). The experiential nature of the learning evidenced in the project demonstrated the value of discovery learning.

Society, and the children's ideas of how our society has changed and functions, is another important factor in children's learning. Wenger (1997, p.38) argued: *'It is doing in a historical and social context that gives structure and meaning to what we do'.* Learning about scientists from different eras through dramatic monologues also helped the children to better understand how society and culture affect their learning and enabled them to gain respect and understanding for scientists' contributions to knowledge. The renewed National Curriculum (DfE, 2013) states the importance of using scientists' work and its significance to children's lives today. The use of drama activities and collaborative work provided shared meanings and understandings negotiated and rationalised through discussion (Jordan, Carlile & Stack, 2008). In fact, the dramatic monologues took the children back in time, where they could experience some of the trials and difficulties faced by the scientists studied, via role play. For example, when studying Jenner (1749-1823) and his smallpox vaccine, having watched a video monologue (BBC, 2012), children acted out the immunisation of the first child (Figure 11), which then led to debate and discussion about ethics at the time and what this would look like in today's world. Children, when asked to create a tableau of the characteristics needed by the scientist, could try to adopt these qualities in their own inquiry. Their learning became culturally sited, as they explored, via drama, the times and culture of the scientist.

When children construct their own idea of a scientist's qualities, and add to their ideas by tapping into their peers' insights, they begin to exert their power of expression. They bring to the tableau their cultural understandings of both the present and the past, as presented via the monologue. They adapt what they think the scientist would have had to do in the face of historical cultural differences, helping them further understand the changes that our world has undergone. In the context of drama activities, the children did appear to construct their own ideas and interpretation of the activities presented. By using drama activities to structure their own ideas of events, then learn more about them in further research and study, children exploited a scaffold to learning, such as Vygotsky proposed in his 'zone of proximal development' (Vygotsky, 1930) and to

Figure 11: Children enacting Jenner's work.

which Wood, Bruner and Ross gave the metaphor (Wood, Bruner & Ross, 1976).

One of the main building blocks of the drama project was the idea of scaffolding learning, introduced by Bruner in the 1950s (Wood, Bruner & Ross, 1976). This aims to bring about understanding, *'providing or scaffolding learning experiences, from which emerge, or are presented, phenomena to feel, see or hear (i.e. to sense) and be reflected upon'* (McGregor & Precious, 2015, p.22). Models can be considered as flexible ways to understand children's knowledge constructions, as they provide scaffolds to guide their understanding of concepts that are difficult for the children to physically experience (Acher *et al*, 2007). Ideas such as the way planets orbit the sun, how the blood travels through the heart, the transfer of micro-organisms in poor hand-washing or the process of fossilisation, can be enacted and modelled to help the children to understand through physical means, helping them engage with and understand a fairly abstract idea (Harlen *et al*, 2015).

Developing thinking skills through skilful questioning to further probe what the children are expressing in their models also helps new learning to develop (Cullinane, 2010). Early social constructivists proposed that children could learn beyond their developmental age, but within their potential of development, by using support from adults and peers and scaffolds (Lee *et al*, 2016). Many of these ideas have subsequently been developed (Driver, 1988), but this idea of modelling in the drama project (Wood *et al*, 1976), where children imitate and try out things themselves to help them clarify thinking and come up with solutions has, on reflection, been seen to be effective. This active and participatory learning can draw on the children's social resources, acting as a scaffold to their learning (Littledyke, 2004).

Conclusion

Reflecting on diverse learning experienced over the several years of the project, and situating it within theorists' and scholars' views, has enabled me to form a clearer understanding of how drama can enhance and support learning in primary schools. The active, collaborative nature of the learning was inclusive and enabled all children to access experiential learning. The diverse opportunities for discussion, as well as development and refinement of ideas, increased their capacity for dialogic learning and reinforced my own understanding of the benefits of dialogic teaching methods. The enthusiasm, curiosity and engagement evidenced in the children's learning have further reinforced my impression that this type of approach is valuable and productive for all children. Incorporating drama into lessons has indeed supported the children to change their ideas and forge new learning in order to produce a better understanding of the world around them, one of the goals of effective primary science education. My reflections upon the learning should hopefully promote similar approaches being used in many other primary schools in the future, as the usefulness of social collaboration in learning, the value of dialogic practices and the use of scaffolding to enhance and deepen understanding are all evidenced.

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Clarysly Deller CsciTeach is a Fellow of the Primary Science Teaching Trust, and ASE member. She completed a Master's degree in Education Leadership at the University of Manchester attaining Distinction in 2017. She has been a primary school teacher and science leader for 15 years and is now working as a senior lecturer in Primary Science Education for Initial Teacher Education at Manchester Metropolitan University.
E-mail: clarysly@btinternet.com or c.deller@mmu.ac.uk

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