MARTIN BRAUND

DARWIN-INSPIRED DRAMA

Towards one culture in teaching and learning science

> Both the known and the unknown, the two worlds of our ancestors,
> nourish the human spirit. Their muses, science and the arts, whisper:
> Follow us, explore, find out.
>
> (Wilson, 1998:233)

The relationship between ‘The Arts’ and ‘The Sciences’ has both fascinated and troubled educationists. Darwin’s connection with the Arts changed radically over his lifetime. In his early years he embraced cultural activities loved by so many early Victorians. But later, as his science advanced, he became increasingly estranged from poetry, literature and theatre. Darwin’s changing and ambivalent relationship with the Arts reminds us of what C.P. Snow called the ‘Two Cultures’ and the inherent dangers that perceiving this division and continuing it holds for education. In this chapter I show what the Arts, particularly drama, can offer science education. The learner of science benefits from engagement through performance, making abstract concepts understandable as they are connected to personal experiences of mime, dance and acted drama. Engagement through drama also contributes to learners’ realisation of the nature of science and appreciation of viewpoints on scientific issues, thereby enhancing their literacy of science. Darwin’s work and life inspire many examples of this learning. Simulations of survival in nature, plays about Darwin’s life and ideas and role plays about modern applications of evolution and gene selection are examples included in this chapter. These inspiring moments can bring school biology and science to life. However, the biology/science teacher often needs help to make the necessary ‘border crossings’, bridging the pedagogy of the drama teacher to that of the science teacher.

DARWIN AND THE ‘TWO CULTURES’

As a young man struggling to make sense of what others thought should be his professional destiny, first in medicine and later theology, Darwin wholeheartedly embraced the Arts as did many in fashionable society of the early 19th Century. At this stage of life there were no conflicts between his growing interests in science and nature and cultural connections to poetry, opera, ballet, fine arts and theatre. Even when at school in Shrewsbury, the adolescent Darwin turned to the plays of Shakespeare and the poetry of Byron to relieve the tedium of rote learning from the classics and other school subjects, which he found so abjectly boring (Desmond & Moore, 1992: 16). Edinburgh's Theatre Royal provided welcome relief from the horrors of medical dissections by way of ballet or other 'terpsichorean delights' (Desmond & Moore, 1992: 23).

As his interests turned towards science, especially avid collecting and fascination with South American landscapes, plants, animals and fossils on the voyage of the Beagle, Darwin turned to Rossini's operas to relieve the tedium of scientific 'downtime' in Montevideo. In the busy days collecting on the voyage, Darwin expressed his experiences (for example, of summiting the Andes and of collecting in the dense rainforests of Brazil) in terms of the imagery of Tennyson, the landscapes of artist Claude Lorrain and choruses of Handel's Messiah. Darwin often used the term 'sublime' as if to recognise that the beauty of what he saw was beyond mere rationalisation and theory.

Yet, after the Beagle's voyage, as he became progressively more engrossed with validating evidence and constructing theory, Darwin became noticeably estranged from the Arts. For example in a letter to Joseph Hooker in 1868 he wrote:

> I have tried lately to read Shakespeare, and found it so intolerably dull that it nauseated me. I have also almost lost my taste for pictures and music. I am glad you were at the 'Messiah', but I dare say I should find my soul too dried up to appreciate it; and then I should feel very flat, for it is a horrid bore to feel as I constantly do, that I am a withered leaf for every subject except Science. The loss of these tastes is a loss of happiness. My mind seems to have become a kind of machine for grinding out general laws out of large collections of facts. It sometimes makes me hate Science.
>
> (Darwin, cited by Fleming, 1961: 219)

It seems that as his science progressed Darwin increasingly set the atomising nature of his science above the integrating vision provided by the Arts. Fleming likens Darwin's atrophy for aesthetics and estrangement from the Arts as transformation from an aesthete and broader intellectual, able to draw equally on science and the Arts, to an 'analytical man' concerned only with scientific facts and theories. Hence, the title of Fleming's paper, 'Charles Darwin, The Anaesthetic Man' (1961). It seems that later, in his increasingly scientific life, Darwin could not find the emotional space or mental capacity to integrate the Arts, yet this was the very aspect of intellectual life that might have made him more emotionally complete and at peace with himself at a time of increasing self-doubt. Towards the end of his life his regret for not having embraced the Arts is plain to see. In his autobiography, published after his death, he wrote:

> ... if I had to live my life again, I would have made a rule to read some poetry and listen to some music at least once every week; for perhaps the parts of my brain now atrophied would thus have been kept active through use. The

> loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature.
>
> (Darwin, 2005: 115)

The 'Two Cultures'

In many ways, Darwin's changing relationship with the Arts is a fascinating example in a debate that has continued to affect educational thinking for some time. The schism in western intellectual thought, seen as a cultural divide between the Arts and sciences, found its most famous expression when physicist and novelist C.P. Snow delivered his landmark Rede lecture on *Two Cultures and the Scientific Revolution* at the Senate House, Cambridge in May 1959. For Snow it was mainly the ignorance and lack of education in the sciences, particularly for the 'governing classes', that was his chief concern. While being well versed in the classics and the Arts were seen as essential attributes for those who wanted to get on in society, ignorance of science and the fundamental principles on which the world works were seen as conferring no real disadvantage.

The perception that studying the Arts is intrinsically and intellectually different to studying sciences stems from a world view in which thought is divided into two separate realms. As Morris puts it, the first (the science one) is "tangible, measureable and real and the other (the arts one) is immaterial, intangible, unquantifiable and imaginary" (Morris, 2006: 152). In this way science is seen as a reductionist enterprise reducing the world, as Darwin started to do, to its most simple and understandable parts. But, as Darwin soon realised, grand ideas such as his require much synthesis and integration of parts to create a whole. Science is then a more creative enterprise, yet few science teachers in schools or their pupils seem to recognise the creativity of science. It is no wonder that poorer attitudes of pupils to science are the result, particularly when studying science gets harder and seemingly more remote from the real world it is supposed to explain.

A more enlightened view of science ought to take in how it has changed in the history of human thought. Czech scientist and poet, Miroslav Holub, sees science as best understood in terms of a slow transition involving three paradigms (Holub, 1993). The first scientific paradigm was essentially that of the Greeks, that today would be regarded as more philosophical than scientific, being based more on axioms from which theorems could be deduced by the application of logic than on empiricism. Holub sees this first science being gradually replaced by the science of the Renaissance, relying more on measurement, observation and the empirical testing of competing hypotheses. This second scientific paradigm is still dominant and characterises much of present day school science and, I would argue, is partly responsible for its sterility in the eyes of many pupils. Holub's third science includes post-classical physics in which unpredictability and more open-mindedness abound.

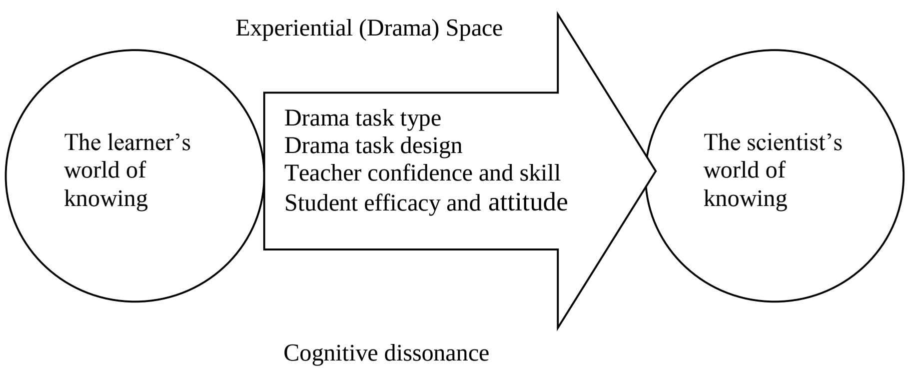
Here there are critical roles for imagination, metaphor and analogy. Words don't and cannot now mean all they normally stand for and the steadfast language of the second science, including the conventions of, for example, equations and chemical formulae, are not enough. The language of science and its capacity to explain through traditional methods is under stress. It is here at this level that the Arts, especially drama, have potential for learning science.

WHAT DRAMA CAN OFFER LEARNING IN SCIENCE

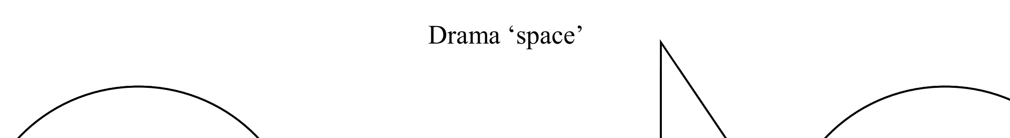
A Model for Drama and Learning Science

Learning science can be seen as rationalising between two worlds of knowing: the learner's world and the scientist's. The learner's world draws on everyday experience, commonly used terms and language and what has been gleaned from science as presented knowledge from media and from family, friends and school. The scientist's world of knowing, which is the eventual target for learning change, has specific rational explanations for the world based on applications of concepts and theories mediated through empiricism. A model to represent this view of learning science is shown as Figure 1.

Figure 1. A model for drama as a way of learning science



In this model, 'cognitive dissonance' is the 'distance' between the two worlds of knowing and the 'experiential space' is the nature of activity and effort, used by the teacher, to reduce the amount of cognitive dissonance and so close the gap between the two worlds. Of course the experiential space could be occupied by any one of a



number of teaching methods: group discussion, practical work, watching video, computer work, board work and so on, but in this case it is drama that is the chosen method.

The central arrow of the model in Figure 1 represents aspects of drama as a pedagogical tool most likely to affect learning. Many science teachers are nervous of using drama methods to teach science either because they believe the class will descend into chaos or, at a deeper level, they may believe that they lack the pedagogical skills and training of the drama teacher that can make these methods work. As suggested by Figure 1, understanding the nature of the type of drama to be used (scripted plays, scripted role plays, improvised role plays, physical simulations, mime and dance), how the task is planned and designed and the teacher's confidence and skill at organising, deploying and debriefing activities are all important. Pupils' efficacies and attitudes to the task, in this case drama, always affect outcomes, but there is a feeling of many who have used these techniques that this is not so much of a problem. So far, drawing on this model, there has been hardly any research into how drama might work best in science classrooms, though some recent work by the author and colleagues is available to suggest how teachers can make the most of the Darwin-related activities discussed later (Abrahams & Braund, 2012).

How Drama Helps Science Learning

Reviewing literature on drama in science, Marianne Ødegaard sees drama contributing to three areas of learning: about *concepts,* about the *nature of science* and about *science's interactions with society* (Ødegaard, 2003). There is some evidence that Ødegaard's first justification for science drama, *conceptual understanding,* is advanced through use of drama. For example, simulations to understand circuit electricity have been used with teacher education students and pupils in primary schools and improved understanding of current, voltage and resistance has been found (Braund, 1999). In biology, concepts in photosynthesis and about cell division (Ødegaard, 2001) have been advanced using drama activities. Improvement of learners' understandings of ecological concepts, such as feeding interrelationships, has been noted from using role plays where learners act out the components and interrelationships of food chains and webs (Bailey, 1994).

As far as educating about the *nature of science* is concerned, Ødegaard claims that 'stories of science' offer learners new insights into the reality of the processes of scientific practice (Ødegaard, 2003:85). Solomon, Duveen, Scott and McCarthy (1992) see activities, such as plays about the history of science, challenging positivistic-empiricist views as they show how science theories have been developed and are open to challenge and re-construction.

The use of drama to teach about *science's interactions with society*, Ødegaard's third justification, has been said to improve pupils' empathy and identification with socio-political situations of science and even to have the capacity to challenge or change learners' world views (Aikenhead, 1996). In South Africa lessons have been observed where role plays helped raise the content and level of argumentation about the ethics of trade in organs for xenotransplantation (Braund *et* *al*., 2007). In a similar vein, analysis of students' discourse following short role plays on who should have rights of access to genetic information have been seen to help in development of group argumentation skills (Dawson, Hill, Barlow & Weitkamp, 2009). Thus, drama can help in the deployment and development of argumentation in science by anchoring scientific debate and ideas in pupils' real worlds (Duschl & Osborne, 2002).

TEACHING DARWIN-RELATED SCIENCE USING DRAMA

In this section I provide examples of drama activities to teach about Darwin, his life and ideas and to address controversies in modern science related to evolution and genetics. Activities link with Ødegaard's three purposes for science drama described above using types of drama commonly seen in school science: scripted drama, defined role play discussions and simulated role play/games. Each of the activities is discussed in relation to some of the literature suggesting effective ways to use drama and emerging research.

Teaching Concepts: Using Simulation Role-Play/Games

The idea of using simulations, that are effectively types of games, is that they provide analogues for the concepts to be learned (Braund, in press). In the first example, of 'Reed Warblers and Cuckoos', the concept is colour variation conferring different survival rates of prey (caterpillars) so that individuals with better survival chances are more likely to breed. In the second example, 'The Blackbird Game', the concept concerns survival behaviour of birds that again confers differential survival and better breeding chances. In both cases pupils' roles are to 'play' organisms involved in prey selection. Science teachers have often used analogy or metaphor in their teaching to try to connect pupils with, sometimes abstract, ideas. The value of drama is that these methods provide memorable, enjoyable and highly active examples where pupils are part of the process the teacher wants to explain.

Teachers often like to use warm-up activities to get pupils tuned into these teaching methods. This can involve practising a pre-version of the game or a slightly different activity, for example such as 'fruit salad', where each pupil sitting in a circle of the class is given the name of a fruit and at the call of that fruit's name must go to the centre of the circle. [For descriptions of these 'warm-ups' see Index 1 of *Performing Science*, Abrahams and Braund, 2012: 125-131]

Reed warblers and cuckoos

This game-simulation can be played outside or in a classroom or school hall and is suitable for pupils in the age range 11-16, depending on the level of the concepts developed. The idea is that a pupil or the teacher plays 'the cuckoo' who wears a 'tongue' made from card carrying *velcro* strips to which the caterpillars collected as prey by the other pupils playing 'reed warblers' are attached. A teacher acting as the cuckoo is shown as Figure 2.

Figure 2. The 'cuckoo' showing the card 'tongue' with captured wool 'caterpillars' attached.

The game starts when the cuckoo calls "feed me". The 'reed warblers' search for and capture caterpillars, represented by different coloured wool strands (about 15 in each of 12 different colours should do), some brightly coloured which stand out against various backgrounds, others having more camouflaged colours. The rule that reed warblers can only retrieve one caterpillar at a time to return to the cuckoo's tongue helps prevent over-zealous collection of bunches of caterpillars. The wool 'caterpillars' can be stuck onto the cuckoo's tongue from top to bottom in order of retrieval, providing a record of colours of prey selected as predation continues. The patterns can be discussed in terms of changes in relative selection pressure as more brightly coloured and obvious individuals are selected out. If the game is played in the school grounds, then a distinct area can be pegged out that includes grass, bushes and trees, and any remaining caterpillars on each background can be counted when the game has terminated. I have seen the game played in a classroom where camouflaged military netting was suspended above pupils' heads with the wool 'caterpillars' laid just inside the netting.

A feature of drama, like some other interactive learning activities, is that it has potential to generate additional misconceptions through comparison with reality. In this case it is necessary for pupils to appreciate that cuckoos are not normally fed by more than one pair of reed warblers. How good the drama is as an analogue for nature can be part of discussion that follows the drama-game. In some of my observations of drama used in science classrooms I have noticed that teachers do not spend enough time debriefing or discussing the drama. This was particularly noticeable for student teachers who were drama specialists. They seemed to assume that the potential of the drama to establish learning was so powerful that nothing else was needed to embed concepts or address shortcomings of simulations (see Braund *et al*., 2013). As with most learning events, consolidation by the teacher and reflection by learners makes fuller impact of the activity more likely.

The blackbird game

As with the previous drama this simulation-game deals with survival chances of prey animals. In this case predation is related to evolved and inherited behaviour: blackbird flight patterns in woodland. The game can be played by any number, but if the class is large you can use two or more groups. The concepts can be extended for more able and older students and the basic game is suitable for pupils aged from 9-14.

Ten to fifteen pupils are arranged in a large circle. These pupils represent trees in a wood or forest. The space inside the wood is a clearing. Blackbirds are fist-sized, 'scrunched-up' balls of black paper or bean bags given to about half of the pupils acting as trees. A warm-up activity might be to practise throwing and catching the 'birds' around and across the circle. A pupil is asked to enter the centre of the circle to play the predator, a 'sparrowhawk'. The game starts as one 'blackbird' is thrown around the circle from one pupil acting as 'a tree' to another who must catch it. The aim is for the 'sparrowhawk' to catch the 'blackbird' before it reaches the safety of another 'tree'. Once a blackbird is caught it is removed from the game. The teacher can establish rules to prevent the sparrowhawk from grabbing blackbirds when not in flight or to deal with sparrowhawks who are too good at catching the prey by telling them they can only catch with one hand.

I like to play the game several times without much direction to see if the 'trees/blackbirds' can learn that, if they throw short distances around the circle, rather than throwing across the open circle, the prey has more chance to survive. If this doesn't happen naturally, I 'direct' a few 'trees' to start doing this. Later in the game I progressively ask more than one tree to throw blackbirds ending up with all of the blackbirds simultaneously 'flying' around and across the circle. This is great fun and good for pupil concentration and catching skills. The selection-survival point here is that flocking behaviours have evolved to make it difficult for predators to seize a bird from a host of fast moving individuals. This stage of the game is shown in Figure 3.

Figure 3. Pupils playing the 'blackbird game'. At this point the 'sparrowhawk' in the centre of the circle is trying to catch one of the several 'blackbirds' thrown by 'trees'.

As an extension or for differentiation, a white ball of paper, representing an albino-mutant blackbird can be introduced to the game. You should find that the white mutant, even in flocking behaviour, is selected/predated more than each black one. The discussion following the game can include questions on why mutant blackbirds are so rare in the population (because so few of them survive to breed and pass on their genes and so are selected out).

Teaching About Darwin's Ideas and the Nature of Science: Using Scripted Plays

Fels and Meyer's prediction that many science teachers find it hard to adopt and use a pedagogy of drama for science lessons (Fels & Meyer, 1997) might mean that science teachers are more nervous of types of drama with high rates of pupil autonomy and interaction, such as in the games described above. Perhaps the 'safest' form of drama to start using, for more reticent or less practised teachers, is the 'scripted play'. This is where I started my personal journey in using drama to teach science. From this there is a progression, as experience and confidence grows, to using role plays where the roles and ideas are suggested (see later) to freely improvised drama simulations where the scenario, phenomenon, event or process is provided but pupils make up their own ways of showing these (see Abrahams and Braund, 2012: 1-5).

For some time, teaching about the ideas of science and how they came about has been seen as an important component of learning science. This found its most obvious expression in the national curriculum of England when a section called 'How Science Works' was introduced in 2000. Behind teaching about the ideas of science is the contention that a science education that does not recognise the intellectual efforts made by scientists, both in the present and in the past, to contribute to knowledge and provide explanations for scientific phenomena is, at best, only partially valid and, at worst, intellectually bereft. In the words of Osborne, Erduran and Simon, who produced a teaching pack developing this style of teaching:

> To ask school students to accept and memorise what the science teacher says without any concern for the justification of those beliefs is poor currency. Poor currency because it leaves them unable to explain those beliefs to anybody else but, more importantly, poor currency because it fails to lay bare the enormous intellectual achievement of those who first realised the scientific explanation and the struggle they had in winning the hearts and minds of a sceptical public …
>
> (Osborne *et al*., 2004, p. iii)

So it is important for pupils to see that the ideas of Darwin did not exist, frozen in time, in a historical vacuum. Darwin pondered the ideas of Lamarck to see how his ideas challenged these. His ideas in turn challenged Christian fundamentalist orthodoxy of the late 19th Centrury and still do. Today, there is more evidence of evolution and modern genetics provides explanations for variation and selection, though Darwin's esential notion of speciation through natural slection remains one of the most robust theories of science.

To teach about Darwin's ideas and to show how these ideas developed and are seen by some as controversial, I wrote four short plays, orginally intended for the Salters Science teaching scheme on Evolution for pupils aged 14-16. The plays and the accompanying teachers' guide and pupils' questions are available on the website for *Performing Science* (Abrahans & Braund, 2012: 28-29) or can be obtained from the author by an Email request (address at the end of this chapter). In the first play, 'The Giraffe's Long Neck', players discuss how ontological reasoning, that organisms evolved features to fit changes in the environment, might explain how different extant and extinct organisms came about and how these ideas were regarded as heretical at the time. The second play, 'The Voyage of The Beagle', deals with the relationship between Darwin and his father, who was originallly opposed to the trip, and Fitroy, The Beagle's captain. 'The Great Debate', the third play, deals with Darwin's reluctance to publish his great idea and how his friends encouraged him, focussing finally on the defence of '*The Origin*' by Huxley in the well known debate with Bishop Wilberforce at the Oxford Union. The final play, 'Whatever Happened to Genesis?', shows that Darwin's ideas continued to be and still are challenged by creationists. The example in the play is the trial of Tennessee biology teacher John Scopes who was brough to trail in the 1920s for attempting to teach evolution according to Darwin.

The idea is that these plays are used to stimulate discussion, rather than as polished dramatic performances. Drama through plays has most power in science teaching when pupils are actively involved to construct 'holistic empathy'; in other words, they may have empathy with the characters they play, but they also construct an understanding of the story as a whole and its true meaning from the entire narrative. I have found it best to allocate each play (which has from 6-8 parts) to a different group of pupils and then to get each group to read, prepare and reharese, if they want, and finally to perform to the rest of the class who can ask questions about the play and the ideas and controversies represented.

Teaching About Darwin as Part of Science's Interactions With Society

One of the justifications for a science education for all is based on a broader rationale than just to educate an elite set of pupils from which to recruit future generations of scientists and technologists. In this broad rationale the public understanding of science is seen as important to equip school leavers with the ability to engage in debates and take decisions based on science that is most likely to impact their lives. An example of this 'life knowledge' is about genetic selection, one of the twenty-first century's most important post-Darwinian legacies.

The Y Touring Company funded principally by the Wellcome Trust has been active in facilitating uses of drama in the public understanding of science. For example, they have been leaders in using short plays, digitised as films, to focus debate for learners about uses of biotechnology and thinking on bioethics. Evaluation shows there have been specific and marked shifts in learners' attitudes to science as a result of pupils' engagement in these activities (Reiss, 2010). One of their earliest plays, *The Gift*, tells the story of three generations of the Kaye family affected by a genetically inherited disease called Friedreich's ataxia (see: www.geneticfutures.com/thegift). One child of the Kaye family, Annie, inherits the double recessive form of a gene causing the ataxia from her parents who are both heterozygote carriers. The lack of a dominant gene in Annie means the defect is fully expressed and the condition affects her cerebellum, causing loss of balance and muscular coordination. This is devastating news for her and her family, in part because Annie is a very talented sportswoman destined for future honours. Annie's brother Ryan, who is not affected by the condition but carries the recessive gene, is devastated by news of Annie's inheritance and later in life becomes a geneticist dedicated to treating and eradicating genetic diseases. When he marries he is shocked to find that his wife also carries the recessive gene for Friedreich's ataxia.

Using his knowledge and position as a geneticist he puts his wife in for treatment for superovulation, whereby she produces several ova one of which he selects for fertilisation as having the dominant (good) gene for the condition. This is legal but he goes further in selecting one of the fertilised embryos for gender and for genetic traits conferring extreme athleticism. Thus Ryan is charged with going beyond the geneticist's code of conduct by operating 'genetic selection' for what he sees as additional benefits for his family. Much later, the son Mark, the result of this 'selection', finds out about his father's actions and is upset, regarding himself as some sort of 'freak of science'.

There are a number of ways of using materials associated with *The Gift* to teach about genetics and bioethics. The genetics futures website provides a full script of the play, a digitised downloadable film, newspaper articles telling various aspects of the story as it unfolds in time, a synopsis and role cards for each member of the Kaye family. I think one of the best ways to use the materials is to provide a synopsis of the story and go over it with the class and provide some of the news articles for them to read – this could be done as pre- lesson homework. In class, groups could role-play members of the Kaye family as they meet to consider Mark's situation and his feelings about being a 'genetic freak'. Some license might be needed here as some family members, particularly Annie, would probably not be alive in Mark's time!

As noted for the Darwin plays discussed in the last section, it is important for each role player to establish holistic empathy through the whole storyline rather than only having empathy or antipathy with their own roles. Whole class discussion of the ethical issues that emerge from the outcomes of discussions and opinions expressed from each group should be principal outcome, rather than arriving at a right or wrong resolution to whatever question the teacher poses.

ONE CULTURE FOR LEARNING SCIENCE

Even after explaining the virtues and advantages of using drama to teach science, including extensive drama workshops, I still find a persistent 'two cultures' rhetoric. One of our student teachers in South Africa said this:

> I don't really see where the link is with drama. I spoke to my husband about it and he's an engineer ... so he just loves the science and maths and everything and he says he also can't make the link because to him science is content and I do think it's like that … it's like science is a serious subject and drama is just for having fun.

I am not saying this opinion is typical, but it does seem that for some teachers drama goes beyond what they are prepared to do to teach science. It could be that the student teacher quoted above just has a view of science that precludes any kind of interactive teaching that is pupil-centred. She may also assume the didactic transmissive methods that led to her own success at school are appropriate to use with her pupils. I have found this 'teach as I was taught' view to be quite a common feature among trainee teachers.

However, there are some rays of hope for the future of science teaching. The two cultures view is beginning to break down. For example, Nobel astrophysicist George Smoot sees the two cultures idea as outmoded, irrelevant in the modern world. Smoot claims we are entering a 'third culture' more heavily dominated by science and technology:

> Basically, in terms of whatever war [between the two cultures] has been going on, I think it is has finished. I don't characterise it by saying we [the scientists] have won. I think everybody has won. We are living in a profound science culture and the big events that are affecting people's lives are scientific ones.

(Tim Adams in The *Observer*, 1 July 2007)

For Smoot's view on science to result in a more modern science education, teaching will needs to move to one culture for learning, one which truly embraces the advances in our understanding of the psychology of learning. In an article with Michael Reiss (Braund & Reiss, 2006) we argued that, while our understanding of the ways in which pupils learn science advanced in the second half of the twentieth century, the paradigm for teaching science in schools remains stuck with a late nineteenth century view of science, seen mainly as laboratory-based activity and reductionist principles. In contrast, science today is multidisciplinary and located in a number of situations that include field work, computers, discussion and thought experiments as well as lab work. Unfortunately for pupils in many schools Darwin, if he were alive today, would recognise and feel quite comfortable with much of what goes on in the name of school science.

It is widely recognised that the Arts, including drama, play a significant part in developing overall intellectual capacity. The contribution of drama to creative and critical thinking, including advancing skills in scientific argumentation, is of particular importance (Duschl & Osborne, 2002). In South Korea there is a government initiative aimed at fostering students' creativity through the inclusion of arts subjects in a STEM-focused curriculum. The idea is to broaden the curriculum from 'STEM' to 'STEAM': Science, Technology, Engineering, the Arts and mathematics.

Darwin's work, his life and his ideas lend themselves to learning activities that involve learners in highly interactive methods. Drama activities are memorable not only because they can be highly enjoyable but because they help establish meaningful and long-lasting links between the science and the dramatic events. As a pupil having just completed a drama in science lesson put it:

> I liked doing the drama because you can learn and you can do it yourself. It's a quicker way of learning than from books and stuff even from video … You will know what it would feel like and that kind of thing, like maybe we could remember about how we moved and how we acted in the grade exams.

Perhaps dramatic Darwin activities might even improve pupils' performances on examination questions about selection and evolution. But I hope that examination success is not the only justification for a more holistic science education that embraces and uses the Arts.

REFERENCES

Abrahams, I. & Braund, M. (2012). *Performing science: Teaching physics chemistry and biology through drama* (pp. 46-49). London: Continuum.

Adams, T (2007) *The new age of ignorance*, The Observer Newspaper, 1st July 2007.

Aikenhead, G. (1996). Border crossings into the subculture of science. *Studies in Science Education*, 27, 1-52.

Bailey, S. (1994). *The Ecogame*. Risley, Warrington, Cheshire: BNFL Education Unit.

Braund, M. (in press). Drama and learning science: an empty space, *British Educational Research Journal*,

Braund, M. (1999). Electric drama to improve understanding in science, *School Science Review*. 81(294), 35-42.

Braund, M. & Reiss, M. (2006). Towards a more authentic science curriculum: the contribution of out-of-school learning, *International Journal of Science Education*, 28(12),1373–1388.

Braund, M., Lubben, F., Scholtz, Z., Sadeck, M. & Hodges, M. (2007). Comparing the effect of scientific and socio-scientific argumentation tasks: lessons from South Africa. *School Science Review*, 88(324), 67-76.

Braund, M., Ekron, C., & Moodley, T. (2013). Critical episodes in student teachers' science lessons using drama in grades 6 and 7, *African Journal of Research in Mathematics, Science and Technology Education*, 17(1-2), 4-13.

Darwin, C. (2005). *The Autobiography of Chales Darwin*, Barnes and Noble Publishing.

Dawson, E., Hill, A., Barlow, J., & Weitkamp, E. (2009). Genetic testing in a drama and discussion workshop: exploring knowledge construction. *Research in Drama Education*, 14(3), 361-390.

Desmond, D. & Moore, J. (1992). *Darwin*, London: Penguin Books

Duschl, R. & Osborne, J. (2002). Supporting and promoting argumentation discourse, *Studies in Science Education*, 38, 39-72.

Fels, L. & Meyer, K. (1997). On the edge of chaos: Co-evolving world(s) of drama and science,
Teaching Education, 9(1), 75-81

Fleming, D (1961). Charles Darwin, The Anaesthetic Man, *Victorian Studies*, 4(3), 219-236.

Holub, M. (2001). Poetry and science: The science of poetry/the poetry of science. In K. Brown (Ed.). *The measured World: On Poetry and Science*, 447-68. Athens: Georgia: University of Georgia Press.

Morris, A. (2006). The act of the mind: Thought experiments in the poetry of Jorie Graham and Leslie Scalapino, in R. Crawford (Ed.) *Contemporary Poetry and Contemporary Science*, 146-166. Oxford: Oxford University Press.

Ødegaard, M. (2001).The drama of science education. How public understanding of biotechnology and drama as a learning activity may enhance a critical and inclusive science education. Unpublished Dr.scient. Dissertation, Norway: University of Oslo.

Ødegaard, M. (2003). Dramatic science. A critical review of drama in science education. *Studies in Science Education*, 39, 75-101.

Osborne, J., Erduran, S. & Simon, S. (2004). *Ideas, evidence and argument in science (IDEAS PROJECT)*. (London: Kings College, University of London)

Reiss, M. (2010) Science education, theatre and 'Y Touring'. Available online at: www.theatreofdebate.com/ytouring21/Blog. (accessed 10th February 2012).

Solomon, J., Duveen, J., Scott, L., & McCarthy, S. (1992). Teaching about the nature of science through history: Action research in the classroom. *Journal of Research in Science Teaching*, 29, 409-421.

Wilson, E.O. (1998). *Consilience: The Unity of Knowledge*, New York: Alfred K. Knopf.

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