
The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2015

Volume 2, Pages 13-17

ICEMST 2015: International Conference on Education in Mathematics, Science & Technology

A NEW STEAM AGE: TOWARDS ONE CULTURE FOR LEARNING SCIENCE

Martin BRAUND

E-Mail:icemstoffice@gmail.com

Cape Peninsula University of Technology, Cape Town, South Africa

ABSTRACT: In many cultures learning has been organised around subject disciplines broadly conceived as the Arts, Humanities and Sciences. Subject disciplines of the curriculum have evolved structures and characteristics creating boundaries between them that are counter to the experiences of many adolescents, who rarely meet such borders in their daily lives. Disciplinary borders favour a utilitarian view of knowledge and creativity, often under-valuing some disciplines, including the creative and performing arts, not directly associated with primary means of economic production. The borders between self-reinforcing disciplinary structures result in inadequate attention paid to the potential of working across, between and beyond disciplines. In this paper I examine how this schism between the ‘Arts’ and ‘Sciences’ has come about and the potential harm it continues to do. An example from the history of science, the case of Darwin’s changing relationship with the two cultures, is used to promote the benefits of more creative approaches to teaching science in a new project, ‘Darwin Inspired Learning’. The benefits to learning science using methods from one of the Arts, drama, are shown. The argument is made for ‘**STEAM**’, showing how education in the 21st Century is moving away from a restricted notion of STEM (Science, Technology, Engineering and Mathematics) to one that encompasses the Arts (Science, Technology, Engineering, **ARTS** and Mathematics). **STEAM** promotes economic development, encouraging people to work creatively to generate and communicate ground breaking new ideas. It is argued that teaching methods and content from arts subjects should be used to promote a more engaging and cognitively challenging experience of science education at a time when poor pupil attitudes to studying science subjects continues to be an issue in many countries.

Key words: science education, teaching innovation, drama, curriculum.

INTRODUCTION

In the history of education there has been a constant intention to create a curriculum representing the cultural, intellectual and social activities characterizing our world and to prepare future citizens to profitably live in it. From the muses of the Ancient Greeks, who provided inspiration for the intellectual pursuits of poetry, astronomy, dance, comedy and history (among others), through ecclesiastical thinkers of medieval times and pedagogues such as Comenius and Rousseau, to the school curriculum of the present day, the Arts and the Sciences have been seen as essential in educating the rounded human being. A problem has been that these two fields of learning and endeavor have tended to be seen as alternative, competing fields rather than as complementary and interrelated. It is important to make clear right from the start that I do not make a case for science and the Arts being the same in the way they proceed or what they achieve. Science is not like Art. Though science is socially and culturally embedded, it produces knowledge through empirically testing ideas to produce better understanding of the world. The science of the universe in the 21st Century is better now than in the time of Aristotle, Ptolemy, Copernicus or Galileo. Art is not like that. Although technology may provide more advanced representational techniques, the paintings of Pollock or Renoir are not better than those of Giotto – they are just different; open to aesthetic rather than empirical judgment and validation. It seems that the separation in schools between the Arts, the sciences and humanities is most noticeable at the secondary school level where subjects appear to be learned in disconnected silos where skills and knowledge exist as separated entities. It is my contention in this paper that the subject boundaries created around school subjects are artificial, created and maintained by those with vested interests and associated power, and that these boundaries harm the progress of all learning especially of science. In a world where technological innovation is fast evolving and drives economies, science increasingly draws on the Arts to provide the creative stimulation for new ideas and

- This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 Unported License, permitting all non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

- Selection and peer-review under responsibility of the Organizing Committee of the conference

*Corresponding author: Martin BRAUND - icemstoffice@gmail.com

even new knowledge of science. The idea of combining Science, Technology, Engineering and Mathematics (STEM), to better contextualize these subjects and draw benefits from collaboration between them, has been around for some time (Bennett, Braund & Sharpe, 2014). In the last four years there is a new letter, 'A' for the Arts, to be added to the STEM acronym. STEAM (Science, Technology, Engineering, 'The ARTS' and Mathematics) is a growth area in Higher Education and industrial and technological communities but, with the exception of some states of the US and in Korea, the concept of STEAM in education and implications for teaching and learning of science in schools lags behind what is happening to science and how it is changing in the real world. After exploring an historic example of how Charles Darwin's science was impacted by the Arts and how this relates to the 'Two Cultures' (Arts and Sciences) concept, an example of how science teaching may be improved by drawing on Arts pedagogy will be discussed. Thus a STEAM example is shown as an achievable reality in modern science teaching.

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. Thus for Darwin the Arts provided not only a holistic experience of culture but also a celebration of the natural world. 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)

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* in May 1959. For Snow it was the ignorance and lack of education in the sciences, particularly for the ‘governing classes’, that was his chief concern (Snow, 1959). 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. From this world view 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.

USING THE ARTS TO TEACH SCIENCE

UNESCO’s decade of educational effort (2005-2014) promoted change based on interdisciplinary effort rather than purely subject-focused innovation (UNESCO, 2005). A central tenet of UNESCO’s resolution was emphasis on holistic teaching practices using multiple instruction methods including those of the Arts. The idea of using methods more normally associated with the Arts to explain science ideas and engage more pupils with science content is not new. Activities involving creative writing, poster art, making 3-D models, science poetry, making animated films and using drama and role play have all been suggested and adopted as part of science teachers’ repertoires (Braund, 2015a). However, the pressure of performance accountability, judging teachers’ on the examination successes of their students rather than also on the extent of their engagement and attitudes to learning, has become increasingly prevalent in many educational systems. This has limited the variety of instructional methods used by science teachers, especially methods drawing on Arts-based pedagogy.

Arts-based teaching helps students learn science because it offers alternatives to the usual expository texts of comparison, description, sequencing and listing, cause and effect and problem solution (Begoray and Stinner, 2005). In contrast, students’ daily lives are dominated by narratives and visualizations associated with films, novels, oral storytelling, television and gaming. Accordingly, it is appropriate to look in more detail at an example from a recent international project which used some of these Arts ideas to communicate and celebrate the work of Charles Darwin.

Arts-based methods in the Darwin-inspired learning project

Darwin-inspired learning was a writing project involving 21 Darwin scholars in the production of an academic and resource book celebrating Darwin’s life and achievements and providing inspirational and innovative ways to learn from and through Darwin’s life and work (Boulter, Reiss & Sanders, 2015). As part of the project the author of this paper was commissioned to write a chapter showing how Darwin’s ideas could be taught using drama.

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). The example provided in this paper is in the first area, though examples for the other two can be found in the full chapter in the *Darwin-Inspired Learning* book (see Braund, 2015b).

Teaching concepts using role-play simulation

The idea of using role-play simulations, that are effectively types of games, is that they provide analogues for the concepts to be learned but in an engaging and learner-centred way (Abrahams & Braund, 2012; Braund, 2015a). In the example shown here, of ‘Reed Warblers and Cuckoos’, the central target concept is colour variation conferring different survival rates of prey (caterpillars) so that individuals with better survival chances are more likely to breed. Thus, the simulation acts as an analogue for Natural Selection.

Students’ 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.

The Reed-Warblers and Cuckoos 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 1.



Figure 1. The 'Cuckoo' Showing The Card 'Tongue' With Captured Wool 'Caterpillars' Attached.
(From: Abrahams and Braund, 2012: 43/4)

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, Ekron & Moodley, 2013). As with most learning events, consolidation by the teacher and reflection by learners makes fuller impact of the activity more likely.

CONCLUSION – THE NEW STEAM AGE

A continuing concern in many countries is that, while students recognize the value and benefits of science for society, decreasing numbers of them want to go on and study the subject at a higher level or take up a STEM-based career (Bennett, Braund & Sharpe, 2014; Søberg & Schreiner, 2010). It seems that school science fails to engage school students and is often seen by them as a cold, fact-based subject, boringly taught and stripped of everyday contexts and real-life meaning (Gilbert, Bulte and Pilot, 2011). It is my contention here that an important contributing factor is that the Arts have been isolated from the sciences in the school world, denying science some of the very methods that could make it a more interesting and enjoyable subject without losing sight of having to learn content at a high level. It is widely recognised that the Arts, including the example I have given here of a drama role-play, have 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). This is one of the reasons why, in South Korea, there is now a government initiative aimed at fostering students' creativity and critical thinking 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. Educational systems in other countries, if they are interested in improving science education and at the same time drawing it closer to the innovative and economic collaborations between the Arts and sciences in the real world, should take note of these more collaborative curricula.

I have shown that Darwin's work, his life and his ideas lend themselves to learning activities that involve learners in highly interactive methods. Drama and other Arts-related activities are memorable, not only because they can be highly enjoyable, but because they help establish meaningful and long-lasting links between science and content and learning events. As a student in a South African classroom, 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 and other Arts-based activities might even improve pupils' performances on examination questions, 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.
- Begoray, D. & Stinner, A. (2005) Representing science through historical drama: Lord Kelvin and the age of the Earth debate, *Science and Education*, 14, 457-471.
- Bennett, J., Braund, M., & Sharpe, R. (2014). *Vision for science and mathematics research programme: Evidence Report 3, Students' attitudes, engagement and participation in STEM subjects*. London: The Royal Society. Available online: <https://royalsociety.org/education/policy/vision/research-programme/> (Accessed, 20th December 2014)
- Boulter, C.J., Reiss, M.J., & Sanders, D.L. (Eds.). (2015). *Darwin-Inspired Learning*. Rotterdam/Boston/Taipei: Sense Publishers.
- Braund, M. (2015a). Drama and learning science: an empty space, *British Educational Research Journal*, 41(1), 102-121.
- Braund, M. (2015b). Darwin-Inspired Drama: Towards One Culture in Teaching and Learning Science, In, C.J Boulter, M.J. Reiss & D.L. Saunders (Eds.), *New Directions in Mathematics and Science Education: Darwin-Inspired Learning* (Chapter 21, pages 285-299). Rotterdam/Boston/Taipei: Sense Publishers.
- 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.
- 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.
- Fleming, D (1961). Charles Darwin, The Anaesthetic Man, *Victorian Studies*, 4(3), 219-236.
- Gilbert, J. K., Bulte, A.M.W., & Pilot, A. (2011). Concept development and transfer in context-based science education, *International Journal of Science Education*, 33(6), 817-837.
- 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. (2003). Dramatic science. A critical review of drama in science education. *Studies in Science Education*, 39, 75-101.
- Søberg, S. & Schreiner, C. (2010). *The ROSE project: An overview and key findings*, Oslo: University of Oslo. Available online: <http://roseproject.no/network/countries/norway/eng/nor-Sjoberg-Schreiner-overview-2010.pdf> (Accessed, 10th January 2015)
- Snow, C. P. (1959). Two cultures. *Science*, 130(3373), 419-419.
- UNESCO (2005). *United Nations Decade of Education for Sustainable Development (2005-2014) International Implementation Scheme*, Paris: UNESCO education sector, retrieved 23rd February 2015 from: <http://unesdoc.unesco.org/images/0014/001486/148654e.pdf>