Activating teachers' creativity and moral purpose in science education

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After completing his degree and PhD at Cambridge University, Martin moved to Oxford University as a Research Fellow in Biological and Medical Sciences at Lincoln College. He left academia to pursue other interests and then returned to Oxford in 2005 as the Deputy Director of the Institute for the Future of the Mind, where he ran the research program on the influence of modern lifestyles and technologies on the minds of the young and the old. Now Martin works with schools and systems across Australia, with DEEWR, to provide some of the evidence base for the National Career Development Strategy, and with UNESCO looking at the future of education in the Asia-Pacific region.

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Sonia's work in the area of primary science has seen her in the role of Science Coordinator, Science Facilitator, Project Officer: Primary Maths and Science Strategy, and then as a Primary Australian Curriculum Implementation Officer, working with leaders and teachers on the implementation of the Australian Curriculum. As part of this role, Sonia was responsible for the development of primary science across the state, which included working with Professor Martin Westwell on the development and implementation of the statewide Scientist in Residence program. Sonia has presented at both SASTA and CONASTA annual conferences.

Abstract

Over the past three years, the Scientist in Residence program (a collaboration between the South Australian Department for Education and Child Development, and Flinders University) investigated a model of professional learning in science education that capitalised upon teachers' moral purpose, and drove their creativity. Teachers changed their practice and, in turn, there was a change in the engagement and achievement of the children. The approach described and the resources produced serve to illustrate some of the principles of practice that the teachers drew upon. In particular, starting with the Science as a Human Endeavour strand of the curriculum and using the content of Science Understanding as the vehicle for the development of the scientific thinking were a crucial part of the teachers' success. A shift in teachers' perceptions and practice speaks to the characteristics of the professional learning – making time and space for teachers to achieve a closer match between their classroom practice and their professional identity.

ACARA (n.d.) tells us that the Australian Curriculum 'sets the expectations for what all young Australians should be taught, regardless of where they live in Australia or their background', but it is surprisingly quiet about the purpose of that teaching. Why do we teach the various learning areas and what will be our measures of success? From the platform provided by the Melbourne Declaration (MCEETYA, 2008), in the overview for parents, we are told that:

> The Australian Curriculum is designed to teach students what it takes to be confident and creative individuals and become active and informed citizens ... In the early years, priority is given to literacy and numeracy development as the foundations for further learning. As students make their way through the primary years, they focus more on the knowledge, understanding and skills of all eight learning areas.

Of course, these phrases are vague enough to allow for a range of interpretations, but at one level, the focus on knowledge, understanding and skills seem to be the very definition of an industrial model of education. At a time when, for example, the OECD is supporting education systems to help young people deal with complex, unfamiliar and non-routine situations (Mevarech & Kramarski, 2014), their knowledge, understanding and skills remain necessary but are no longer sufficient.

Challengingly, Laszlo Bock, Senior Vice President of People Operations at Google, highlighted the likely demands of future work in a Google Hangout in which he recently participated (Google Students, 2014):

> The first and most important is what we call general cognitive ability ... intellectual ability, how well people learn, how well they acquire new skills. The second is emergent leadership, characterised not by formal authority but by somebody recognising there's a vacuum or a void and stepping in to fill that leadership vacuum and just as importantly stepping back out of it. The third thing we look for is cultural fit. The idea there is not that we want a monoculture. We don't want everybody to be the same. What we do want is everybody to have a shared sense of curiosity, of conscientiousness, a little bit of humility when it comes to learning and being open to new ideas and that they might be wrong, and that they want to have an impact on the world.

In the context of a world that has these demands of young people, as expressed to some extent in the Melbourne Declaration, it seems there is a widening gap between a curriculum that spells out 'what all young Australians should be taught' and the learning and developmental needs of our children.

The South Australian Department for Education and Child Development (DECD) initiated the Scientist in Residence program to support primary school teachers to reconnect their own professional and moral purpose with the Australian Curriculum: Science. The program ran for several years, and each year's new cohort of teachers was asked to articulate their views on why we teach science at all, the reasons why society invests in science education, and their personal motivations for teaching and, specifically, for teaching science. Without exception, each cohort would have the development of science content knowledge and practical skills as non-negotiable purposes of science education. However, these components were always of relatively low priority. Closer to teachers' moral purpose was the empowerment of young people through, for example, the development of evidence-informed decision-making, future-thinking, creative problem-solving, strategic competence, testing of ideas (from themselves and others), and forming their identity within a changing world, in particular with respect to their use and a potential career that might involve science, technology, engineering and mathematics.

In collaboration with the authors (a scientist and a lead educator from DECD), teachers reinterpreted the Australian Curriculum: Science to find synergies between the documentation and their own moral purpose. As the analyses unfolded, teachers found that the Science Understanding strand of the curriculum contained few connections. However, the Science as a Human Endeavour (SHE) strand either explicitly described some of their reasons for teaching science or was now seen by the teachers as creating an opportunity to express their moral purpose through their teaching. With this viewpoint, the Science Understanding became both content to be understood and a vehicle for the development of the children's development as science learners. That is, in reinterpreting the curriculum in this way, they identified that science education could deliver the intent of the Melbourne Declaration, the empowerment to deal with complex, unfamiliar and non-routine situations as demanded by the OECD, and at the same time be more professionally satisfying. The Science Inquiry Skills had a number of connections to the teachers' moral purpose and, for many, provided the 'glue' that would help bring together the other two strands.

The paradoxical situation in which the teachers universally highly valued the ideas expressed in the SHE strand of the curriculum and yet gave them the least emphasis in their teaching was not lost on them. Some reasons why this may be the case were discussed, including the paucity of quality resources, the influence of earlier curricula and their own science education. The challenge for the rest of the program was to collaborate with other teachers, scientists, and the children themselves to be creative and develop ways to combine authentically all three strands of the Australian Curriculum: Science.

The scientist in residence was used throughout the program in a role that promoted collaboration and disruption, and there was no formal delivery of scientific knowledge to the participants. The group was supported to discuss scientific concepts when a lack of understanding or misunderstanding was identified, and the scientist was able to bring an external academic perspective and knowledge base to these conversations. In addition, the scientist initiated conversations about scientific thinking. For example, the idea of 'misconceptions' was challenged, in that while there are common scientific misunderstandings that clearly exist within the population, they are often appropriate, given the experiences that people have had. Many people still believe that they have five senses because they were told this in primary school, rather than by being asked how many senses they think they might have. Transforming a 'telling' of information to an 'asking' for a suggestion not only promotes more scientific thinking, it is an approach much more in line with learning in a constructivist and conceptual manner. As such discussions progressed, appropriate researchers and others were brought in to add an evidence base to the developing understanding. For example, a science education researcher, Chris Dawson from Adelaide University, was able to help participants draw on recent developments in neuroscience research to see how newly learned scientific concepts do not replace so-called misconceptions but exist at the same time. A key skill for the student, and their scientific thinking, becomes choosing when to use the scientific concept and when to use the everyday concept.

To promote teachers to be creative in their lesson planning and to support them to deal with the challenges created by considering the curriculum in a non-linear way, the team attempted to 'combat entrained thinking' and 'use experiments and games to force people to think outside the familiar' – a recommended response to a 'complicated' situation (Snowden & Boone, 2007). As a thought experiment, participants were presented with a random content descriptor from the Science Understanding strand of the curriculum appropriate for the year level of children they were teaching. For example, a Year 5 descriptor may have been, 'Solids, liquids and gases have different observable properties and behave in different ways.' A group of teachers would discuss how they would normally teach this, perhaps with existing pen and paper resources and/or through a practical investigation. Next, they would be presented with a randomly chosen SHE descriptor, say 'Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives.' In the thought experiment, teachers were asked to develop children's understanding as described by the SHE descriptor using the Science Understanding descriptor as the vehicle for this development. The silence that followed indicated that 'entrained thinking' was indeed being challenged. In this case, after a short pause for thought, teachers' divergent thinking produced a range of possibilities including (i) undertaking a structured discussion in the form of a Community of Inquiry (see below) to find out to what extent the children knew how the properties of a state of matter might be utilised, (ii) identifying technologies in which the behaviour of a state of matter plays a role, and (iii) presenting students with everyday problems where understanding the properties of the states of matter helps solve such problems. For example, why is this area of my garden always flooding during rainstorms? What difference does the air pressure in my tyres make when I am riding my bike? This exercise was not intended as a planning process but as a way to support participants to interpret the curriculum in more creative ways.

This process is formalised in an online tool, The Randomiser, produced by DECD (n.d.-a) to stimulate similar thinking in the first six learning areas of the Australian Curriculum (English, Mathematics, Science, Arts, History and Geography – the latter now subsumed into Humanities and Social Sciences). A second part of the same resource, the Bringing it to Life Tool (DECD, n.d.-b) was also utilised to prompt thinking about the types of questions that teachers might ask of their students, and how the questions might develop from Foundation to Year 10.

This way of thinking about the curriculum was also helpful for teachers when planning for composite and multi-age classes. By starting with SHE, teachers were able to better connect the Science Understanding from the different year levels and create a unit of learning that met the requirements of all years of schooling within the one class group.

Each teacher in the program was supported to take the creative thinking simulated by such processes and turn it to their own practice and lesson planning. The principles to which the group identified and held onto throughout the program were expressed differently from year to year, but there was a great deal of commonality. They included:

- start with the Science as a Human Endeavour Strand
- be vigilant about who is doing the thinking (teacher or student; for example, shift from 'tell' to 'ask')
- promote, recognise and reward creativity
- promote, recognise and reward students asking questions
- promote, recognise and reward students making judgements (for example, through 'non-Googleable' questions) rather than collecting information (through 'Googleable questions')
- use metacognitive strategies – get students to think about their thinking and recognise the need to do 'slow thinking' (for example, Kahneman, 2011), especially to challenge their existing conceptions.

These principles (strategies) were put into action in a number of different ways (tactics) by each participant. Some drew heavily on the Community of Inquiry approach, an idea about the nature of scientific inquiry introduced by philosopher Charles Sanders Peirce at the end of the 19th century (published 1992), broadened into education settings by John Dewey (1902), modernised by Matthew Lipman (2003) as Philosophy for Children (P4C), and taken as the subject of an independently evaluated large-scale randomised control trial in the UK (Gorard, Siddiqui & See, 2015). Through this project, the program group closed the loop and modified the P4C approach to reconnect with Pierce's original conception of Community of Inquiry as a scientific process. Participants in the program used the structured conversation at the heart of the Community of Inquiry to drive student–student interaction in response to a specific stimulus or at the introduction of a scientific idea (to explore their pre-existing thinking). These discussions explored scientific concepts and some of the related issues and opportunities created by the science. They also shaped the questions that would subsequently be investigated and the ways in which they would be investigated by the children.

Other participants focused on 'noticing', and supported their students to slow down their thinking when engaging with the world. For example, a teacher of a Year 1–2 class in the coastal town of Port Lincoln placed hermit crabs upside down on the floor and asked the children not to rescue them or touch them (a challenge to their impulse inhibition). She provided a scaffold for the children to note down what they noticed about the crabs, what questions they had about the crabs and what they liked about hermit crabs. By scaffolding the children's thinking in this way and turning passive observation into active directing of attention and noticing, the teacher helped the children to develop the skills that underpin scientific thinking. She also found that they would write at a higher standard and produce more writing when asked to produce a persuasive text on 'why hermit crabs make good class pets.'

Other teachers asked students to make suggestions where they might otherwise start with sharing content and information. For example, a number of teachers used the *Flanimals* series of books by comedian Ricky Gervais (Gervais, 2006; Gervais & Steen, 2005). These books of nonsense animals created opportunities for children to create their own animals, develop their thinking about the evidence and reasoning that their animal had certain features, and think about the relationships between the features and the animal behaviour. The children still explored the scientific principles of structure-function relationships, classification, growth, change and heredity, but in a way that started with a low floor so that all students could engage with the process and take some ownership of the thinking. This created a platform from which the teachers transferred the learning to more real-world examples. Almost all of the Biology Science Understanding content descriptors from Reception to Year 7 could be introduced through fictional animals. Again, teachers commented on increased levels of engagement from the children, and the amount and quality of their writing.

School leaders noted changes in the participants' pedagogy and language, including more of a focus on asking questions and a higher expectation that children would be playing a more active role within the lessons. As one school principal described:

> There is a changing language that teachers are now using with kids, and there's a change in the language that they're expecting children to use. I've noticed that the teachers' planning is riddled with questions right through that they are wanting to ask or that they want kids to ask. I've observed in classrooms that kids are asking more questions and those questions are actually being documented and put up on word walls or actually highlighted in big labels. Children are finding answers to those from their friends' questions and talking about it. What I've seen in our school is the teachers are valuing, and therefore children are valuing, what other people are saying about their learning. But they're also being

able to express themselves in writing at a far higher level because they've actually thought through the processes of learning. They've actually thought about it and talked about it before they actually come to write it. They're not being asked to document stuff from the onset. They're being asked to wonder and think and question and predict. And that enables them therefore to articulate it more both orally and in writing.

In a post-program interview, one of the participating teachers summed up the value of the program:

It was a transformation of what I thought science teaching was about. I went into the program thinking that science as a human endeavour was a bit of vague fluffy stuff that didn't fit, wasn't useful and couldn't be quantified. I was attempting to stick it on through activities like a comprehension or the things that were in textbooks. I was finding it clunky and disengaging for kids. So I went in as a skeptic. After having my world turned upside down [through the program, I could see] that not only could I teach this stuff but it was going to make my teaching better. The research was useful and I think I had forgotten that teaching should be based on research. Collaborating with other teachers to get a big pool of ideas [was also useful]. I think that it was just that it was deep thinking and being brave enough to say what I am doing is not good enough and here is a way of making it better. The combination of having a real hard look at why we teach science and at my truth of teaching science compared to what I actually do and what I could do [was useful]. We were on a journey that we then wanted to replicate with our own students.

It clarifies your thinking to collaborate with other people. Having to justify my purpose to myself and to others and argue the merits of [my approach] was excellent. There was a lot of discussion and enthusiasm and that dialogue, the time and space, and the triggers to start those conversations were invaluable. I am now a Science as a Human Endeavour evangelist. I can't highlight enough the potential that the Science as a Human Endeavour strand presents for opportunities to teach science in a more engaging way.

Through this program, South Australian teachers were given time to become clear about their own moral purpose as a science educator. In doing so they reinterpreted the Australian Curriculum: Science in a strategic way so that they and their students could be more creative and engaged in their teaching and learning in science. The collaboration with a scientist and lead teacher created some disruption, but also helped the teachers to not lose sight of the principles that they themselves set and the scientific concepts within the Science Understanding strand of the curriculum as they put their learning into classroom practice. The children have become more engaged, active participants in their science education and are achieving more highly against the Achievement Standards in both the quality of work they are producing and the quantity of evidence that they are providing against the standards. The reinterpretation of the curriculum by their teachers is helping them to develop as effective learners and thinkers in science, as envisaged by the OECD and Google, rather than recipients of 'what should be taught'.

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