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Science and Poetry as Allies in School Learning

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Abstract

In this paper, we propose that when learners in school classrooms write up a scientific observation, firstly as a science report and then as a poem, the way they express insights appropriate to each format can advance learners' observation skills and developing insight of the natural world. This could lead to productive learning alliances across traditional discipline boundaries and, by surfacing the cultural dimension of science within a sociocultural frame, promote social change. Tracing the domains of science and poetry over the last two centuries, we discern three areas of synergy: culture, creativity, and the curriculum. An integrative classroom exercise was devised to support these synergies explicitly with the intention of inspiring learners to write (say) what they really mean (see). We describe the encouraging results of a preliminary trial of this writing exercise with one small class of South African high school students, and outline possible future directions for research prompted by this work.

Keywords: Science, poetry, science education, observation, curriculum

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The Call

No words, no words . . .
Poetry!
They should have sent a poet.
So beautiful . . . so beautiful.
I had no idea . . . no idea. (Zemeckis & Starkey, 1997)

In the 1997 film adaption of Carl Sagan's (1985) novel, *Contact*, an astronomer on a scientific mission drifts wide-eyed with awe in the centre of the wondrous Milky Way, calling for a poet to express the glittering grandeur that surrounds her. This reminds the authors of experiences that we had as aspirant scientists, separated by decades and continents: Claire in South Africa in the 1980s, and Miles in New Zealand in the 1960s.

Miles remembers, as a faculty member on an ornithological field trip, being with tertiary students in the Kauaeranga Valley, near Thames, in New Zealand's North Island. Early sunlight streamed through his tent's green canvas onto his sleeping bag as he listened to the dawn chorus of bellbirds and tui in the ancient podocarp forest across the river. To his ear, the music was swelling into a mighty penultimate chord. But the seemingly irresistible resolution never happened. Rather, the music flowed without pause into some other anarchical, avian direction that defied his imagination.

Similarly, Claire recalls, as a university student, standing knee deep in a rock pool on the South African Cape coast assisting her phycology professor record seaweed samples beneath a black velvet sky draped in brilliant splendour. An apprentice scientist, she too searched for a means to describe what she saw, to bear faithful witness for others not there. Scratching stick figure digits in columns on her clipboard in the darkness, she flipped the page to scribble words she could not see, trying to describe the stars afloat in crystal water, swirling with the tide to the delicate caress of seaweed tendrils as they released their reproductive structures, slippery, yet encrusted with diamonds. Her scientific report would not nearly capture the reality of this lunar-cyclic phenomenon. Or could it?

In this paper, we propose that the writing of poetry and of science reports can sometimes be profitably addressed together in school classrooms. Why do we suggest this? Surely, science is about faithfulness to evidence, laudable scepticism, and sober caution; by contrast, poetry embraces flights of fancy, the unrestrained juggling of language, and the proposing and exploring of delicious ambiguities. So, shouldn't it follow that to blend the objective world of science knowledge and the subjective life of the poet—Ernest Rutherford's buzzing laboratory and Dylan Thomas's inimitable cadences—would only blur and confuse both in students' minds?

Science and Poetry: Going Deeper

The tide of history, we argue, is on the side of seeking synergies between poetry and science writing. Two hundred years ago, it was generally fashionable to consider science and poetry as being poles apart. For example, in the 1790s Erasmus Darwin, Charles's grandfather and an early proponent of biological evolution, tried to distance himself from inevitable public odium by publishing his heretical ideas buried in footnotes to mock-heroic poetry (Stott, 2012). Indeed, in 1825 the German poet and critic Friedrich von Schlegel proclaimed frostily that "strictly understood, the concept of a scientific poem is quite as absurd as that of a poetical science" (Von Schlegal, quoted in Gaither & Cavazos-Gaither, 2000, p. 274).

By contrast, the Romantics in early 19th century Europe were seeing a new common ideal of intense, even reckless, personal commitment to discovery, which was drawing science and poetry together into “a single whole which might best be understood by attending to its middle term, imagination” (Midgley, 2001, p. 55). The Romantic imagination was being inspired, not alienated, by scientific advances. Richard Holmes (2011) noted that, in an age of hope and wonder, Shelley was writing speculative essays, mixing scientific ideas with psychology (p. 326); Coleridge (p. 274) felt that science and poetry were desirably intertwining (and vowed enthusiastically to “attack Chemistry, like a Shark”); Humphrey Davy, all through his life, often expressed his science ideas in sonnets and ballads (p. 415); Michael Faraday felt it perfectly natural to write neat light verse during his courtship (p. 401).

Today, reviews strongly suggest that alliances (Armstrong, 2001), crossovers (Crawford, 2006), and cross-pollinations (Nabhan, 2004) between science and poetry, both in the modern world at large (Wheeler, 1999) and in classrooms in particular (Feasey, 2006; Girod, Rau, & Schepige, 2003), can create exciting and productive synergies. There are at least three domains in which this can happen.

One of these is the domain of culture. Whilst a cultural dimension is almost universally seen as the groundswell of the poetry it gives rise to, the cultural dimension of science and science education has often been less clearly accepted—even denied (Tobin, 2007). However, when cultural dimensions (including cultural differences) are acknowledged, negotiated, and acted upon, fruitful and relevant social change can occur. Along with many others (e.g., Hodson, 2011), we maintain that students' classroom learning in a broad sociocultural frame (Barker & Buntting, 2016) that acknowledges a synergy between the cultural underpinnings of both poetry and science is possible and fundamentally necessary to promote social development and change. This adoption of a sociocultural frame of course brings attendant roles for teachers—as anthropologists (Hodson, 2002) and as culture brokers (Jegede & Aikenhead, 2004)—that is, in helping pupils to mediate or negotiate cultural borders and to resolve cultural conflicts that arise in cross-cultural education. We appeal in this paper to the numerous teachers who are now familiar with those roles.

In his 1959 lecture on “The Two Cultures,” novelist C. P. Snow (1998) famously lamented the gulf between scientists and literary intellectuals, and how the British education system was doing little to bridge the gap. Robert Winston, British medical doctor, scientist, and television presenter, recently took up that theme in his 14-part “Scientist’s Manifesto” (2010, p. 387), where he pleaded that today’s scientists, despite how intense and demanding their work has become, need, much more, to view part of their role as being to help nonscientists to see science as an aspect of our culture. And that would happen, Winston believes, if scientists reciprocated by broadening their own cultural awareness and embracing the universal and deeply important values of major literary figures, including poets. This quest for connectedness, Winston (2010) believes, is typified in the words of the Roman poet Terence: “I am a man: nothing human is foreign to me” (p. 522). If that sounds like a novel and austere challenge, many science teachers will be intrigued to know that famous names in science such as Carl Sagan, Richard Dawkins, Richard Feynman, and Stephen Hawkins can already be found on joyful websites, happily negotiating science and poetry in the same breath.[1] In fact, Dawkins describes the “deeply moving,” “good to be alive” view of reality that science affords us as “poetic magic” (Dawkins, 2011, p. 22).

A second domain is that of creativity. In his essay, “On Art and Science,” Jacob Bronowski (1977), a British scientist, historian of science, and playwright of Polish-Jewish origin, saw creativity as the antithesis of the tendency of things in nature to always become disorderly. Creativity is “the finding in nature of links, of likenesses, of hidden patterns[2] which the living thing—the plant, the animal, the human mind—picks out and arranges” (Bronowski, 1977, p. 16). It follows that:

> *the act of creation is . . . the same in science as it is in art. It is a natural, human living act. Yet, of course, a poem is obviously not like a theorem. How does it differ? It has nothing to do with how it is composed; it differs because it matches human experience in a different way. (Bronowski, 1977, p. 18)*

We pick up on this different way below, but the common *how* of creation is highly relevant: "The mind spends a long time digesting the available material, and then the act of creation is an act of finding the right order to express the whole complexity" (Bronowski, 1977, p. 17). And somewhere in this process is something that emerging evidence (Lehrer, 2012) suggests can be nurtured in all of us—the aha moment.

The relevance of a focus on the wellsprings of creativity in the science classroom is clear. In line with other studies (e.g., Milne, 2008), our approach in the present paper has been primarily about the pedagogical implications of creativity but we are well aware of, and are excited by, the epistemological issues (i.e., concerning the status and origins of knowledge) that arise when science text and poetry are viewed together. Far from being solely within the realms of poetry, the notion of metaphor (Black, 1962) is a long-recognised commonality. Its place in the philosophy of science has been interrogated (Hesse, 1966), and the way metaphors become extended into science models—"teasing at first, capable later of seeming very real" (Sutton, 1978, p. 5)—continues to be acknowledged (Halpine, 2008).

And now, closest to home for teachers, is the third domain: curriculum. In common with a worldwide trend, both South African and New Zealand curriculum documents emphasise the importance of making explicit interdisciplinary links between learning areas. The New Zealand curriculum encourages every effort to cast learning as link forming (Fraser, Aitken, & Whyte, 2013). In its "Principles of Curriculum Decision Making—Coherence," the curriculum "offers all students a broad education that makes links within and across learning areas" (Ministry of Education, 2007, p. 9). The South African Revised National Curriculum Statement states the central importance of such links, which "must be made within and across learning outcomes and learning areas. The achievement of an optimal relationship between integration across learning areas and conceptual progression from grade to grade is central to this curriculum" (Department of Education, 2002, p. 13).

Often called *curriculum integration*, this process has been described by Beane (1997, p. xi) as a design that "promotes personal and social integration through the organisation of curriculum around significant problems and issues, collaboratively identified by educators and young people, without regard for subject area lines." Integration, Beane is saying, is desirable but it should be embarked upon with a clear purpose in mind. So, what might that purpose be, in the case of science and poetry?

Our purpose in facilitating the writing of science text and poetry in the classroom was to stimulate students to write, and then reflect on their perceptions of the similarities and differences of poetry and science. This is in contrast to the recently swelling, but more general, body of literature on pedagogical integration between the arts and the sciences: the possibility of shared tertiary courses (Needle, Corbo, Greenfelder, Raths, & Fulop, 2007), a plea for greater depth in learning outcomes (Jaffe, 2013), challenging the image of "the scientist" (Lunn & Noble, 2008), and exploring the nature of scientific and aesthetic experience (Slattery & Langrock, 2002).

Science and Poetry: Towards the Classroom

Bronowski's notion of creativity—scientific or poetic—is mediated by our capacity for observation. Joel Davis (1997, p. 3) put it this way:

> *Poetry and science are closer than most people realise. Many poets and scientists already know this, of course. Most of the rest of us are still trapped in dismal stereotypes of both fields of human endeavour. The deep link between the two is vision.*

British philosopher, Mary Midgley (2001), made exactly the same point: Provided science is not conceived as a "strange, Imperialistic, isolating ideology," then "our visions (our ways of imagining the world)" can be validly expressed either as poetry "which express(es) those visions directly, in concentrated form" or "less directly in all our thoughts and actions, including scientific ones" (p. 1). Again, in passing, we note intriguing epistemological commonalities: vision as expressed in poetry is rightly never dismissed merely because it lacks objectivity. The world of science, similarly aware of fallibility, now guards against the claim that "seeing is believing" (Chalmers, 1999, p. 4).

With this notion of vision in our minds, we realised that Alan Peacock's (2008) article, "Capturing Animals," in the British journal, *Primary Science*, could provide us with a helpful way forward. He advocated beginning with an "experience of the natural world, focus and deepened sensitivity—the perfect combination of science and poetry" (Peacock, 2008, p. 19).[3] Children's magical observations of small animals, fruits, flowers, clouds, streams, all have "the same potential for focussed observation and careful creative communication" (p. 19). Innovative educators have long realised the power of such a process. For example, in the 1950s in New Zealand's rural Northland, Elwyn Richardson's (2012) vision of creative education suggested that "the concentrated study of material from the student's own surroundings" (p. 92) through processes of "observation, discussion, experimentation, and expression" (p. 94) could lead to "close association in the child's thinking with some actual experience or observation" (p. 157). Then comes the writing itself, consciously as either a poem or as science writing. Either way, Peacock recalled the words of poet Ted Hughes who hoped that children would learn "how to try to say exactly what you really mean . . . without becoming false to [yourself]" (quoted in Peacock, 2008, p. 19).

Four purposes for this integrative exercise emerged:

- To invite students to make sustained and detailed observations of something in their natural world and to record their observations as both poetry and as science text.
- To encourage students to appreciate the purposes, differences, and connections between science text and poetry text.
- To invite students to reflect on and record any challenges or benefits of writing science text and writing poetry together in the classroom.
- For us, as researchers, to document any evidence of synergies (alliances, crossovers, cross-fertilisations) in students' science writing and poetry writing.

Science and Poetry: Setting up a Classroom Experience

Lesson planning and context

With these purposes in mind, we planned to trial an integrative exercise where students would learn to, in Ted Hughes' words, "say exactly what [they] really mean" (quoted in Peacock, 2008, p. 19). We planned for approximately three hours of focussed student work, triggered by students observing something from their natural environment (Peacock, 2008), either in the school grounds or in the classroom. If indoors, we would supply students with natural artefacts such as New Zealand moa bones, weta exoskeletons, giant kauri snail shells, an African ostrich egg, a warthog tusk, fossilised leaves and shells, gold bearing rock, and desert crystals. We would also provide books, journals, and online resources for reference purposes.

We received an invitation to offer the exercise to a small class of Grade 11 students at a private South African school. This class had two 45-minute lessons on the same day, the first during their science period in the morning, and the second during their English period in the afternoon. We saw this as an opportunity to pilot the learning exercise and followed the standard ethical procedures to do so.

Without the time to take students out into the school grounds, or for them to examine and investigate artefacts at length in class, we set students an *authentic task* (Herrington & Oliver, 2000) where we immersed students in a scenario by inviting them to first take on the role of a scientist, and then of a poet tasked to record her or his observations for a particular purpose (see Lesson Description below). As our trigger event, we used photographs and short videos of wildlife taken by one of the authors on a recent walking trail in the Kruger National Park.

Desks were arranged in semicircles to encourage students to change their usual positions, to ensure that each student could see and hear the videos and images clearly, and to support student discussion and collaboration.

Our intended learning goal remained unaltered: We are learning to write (say) what we see (mean). This goal was explicitly stated at the start of each lesson as an invitation to the Grade 11 students to participate in a learning experiment.

The students

A small, multicultural class of nine Grade 11 students participated in both morning and afternoon lessons. There were three boys and six girls aged 15 or 16 years. English was not the first language of the majority of students. They were described by their English teacher as “good kids,” very conscientious, with good to excellent English language skills. They were usually quiet and reserved during class activities. Self-expression was encouraged.

Lesson description and student response

Both lessons started with an invitation to the students to participate in an integrative learning experiment as volunteers with a “fun goal” expressed as, learning to write (say) what we see (mean). They were assured that their anonymity would be preserved regarding any writing or verbal contributions made. During the first lesson (usually their science lesson) they were invited to participate as scientists in an imaginary scenario where they were taken to a pristine wildlife environment where animals were threatened with imminent extinction. They were asked to record sufficient data to be able to create and sustain living conditions for these animals to survive in future in captivity.

Students watched three 2-minute videos, and images with teacher commentary while making rough notes. They were asked to describe what scientific writing was like. With teacher guidance, they suggested attributes such as “clear,” “concise,” “accurate,” “unambiguous,” “to be shared as data for verification,” “measurable,” “repeatable,” “objective.” These terms were written on a board where they remained visible for the remainder of the session.

The students were given 20 minutes to work individually or in pairs, preparing a scientific account of their observations. They were deeply engaged in the task. Only three of the nine students talked to one another. Students asked a few questions during this writing time, about the animals and their environment such as, “About how old was the rhino calf?” and “How long did the elephant stay at the waterhole after you stopped recording?” Rough notes we noticed that students made while watching the videos were, “The patient fighting of male giraffes” and “When rhinos stand still they look like rocks.”

During the last five minutes of the lesson, when they were invited to read their accounts to the class, only one student volunteered while the rest continued to write. Clearly, 20 minutes was not sufficient for this task.

Some of the accounts were entitled “Rhino and Calf Behaviour Changes When in Danger” and “Behaviour of Elephants on a Hot Day,” “Endangered Animals Report” or, simply, “Wild Dogs” or “Giraffe.”

During the second lesson (3 hours later on the same day), which was usually the class’s English period, students were again invited on an imaginary environmental mission, this time as poets. They were asked to describe one or more of the animals in a poem so that people in the future would be able to imagine how they lived when they were in the wild.

The students watched the three 2-minute videos again, without teacher commentary afterwards. They made rough notes again. They were then asked to describe what poetry writing was like. With teacher guidance, they suggested that poems had “lines and verses,” and that sometimes the lines rhymed. They mentioned rhythm. Two students laughingly asked: “Is rap a kind of poetry?” Other students suggested that poetry writing had figures of speech, mood and tone, metaphors, similes, comparisons, contrast and symbolism, and that poems held life lessons.

Given that there were only 15 minutes for the students to try writing poetry, the teacher invited students to draft about 10 lines, either on their own or together in pairs. Again, the students worked silently and were deeply engaged in the task, not pausing to ask questions of one another or the teacher. They wrote and rewrote lines, flicking back and forth amongst their notes, and scratching lines through words. Rough notes that students wrote and reworked during this time were “Rhino calf whines like a whale or dolphin” and “wild dog uses truck as bunker.” When volunteers were asked to read some of their poems, all nine students read theirs aloud albeit some, fairly shyly. Some of titles of their poems were, for example, “Playful Beasts,” “No Longer,” and “Graceful Giant.” An example of one student’s poem and science account about rhinos follows:

Graceful Giant

Graceful giant,
not fully grown.
Having so much fun
allowing him to cool
splashing in the sun.

Taken by a gun
held by a fool.
All is said and done
Graceful giant
Not fully known.

Rhino Cow and Rhino Calf

The environment they were in was dry and thorny with small shrubs. Dry and prickly grass and plants. Not many tall trees around that provide a lot of shade.

They are extremely endangered and their horns are therefore taken off or stumped when they are born to reduce poaching for their horns.

Moms are very protective of their calfs and when they pick up the scent of humans they start to back away and make a run for it.

While they are walking in the bush the rhino calf was whining (sounds similar to a dolphin or whale).

White rhino calves walk in front of the rhino cows and black rhino calves walk behind the rhino cows.

Their were two rhino cows and two rhino calves who were near each other but separate when moving and resting.

The lesson concluded with a whole class discussion about “What makes a poem a poem?” “What sorts of things do your poem and your science writing say about the animals?” and “What do you think about writing a poem and a science report at the same time?” This invoked a range of reactions from quietly thoughtful to bemused, but none suggesting they were confused by the exercise. A survey sheet was handed to every student, on which they were asked to write down their thoughts and opinions about these questions. There seemed to be no confusion amongst the students about the writing tasks, topics, or learning goals at any time during either lesson. All the students completed the survey and handed in their poems, science accounts, and completed surveys.

Science and Poetry: Some Learning Outcomes

Our fourth purpose for this integrative exercise was to document any evidence of synergies (alliances, crossovers, cross-fertilisations) in students’ science writing and poetry writing. Trialling the exercise with the small Grade 11 class over two separate 45-minute lessons on the same day limited the time students had to observe, reflect, and write. Also, they had to immerse themselves in an imagined scenario rather than make sustained, direct observations of the natural environment. Given these adaptations, we were heartened by the students’ commitment to the writing tasks. Perhaps this response was due to the gravity of the environmental issue in the scenario, with the plight of the animals and their habitat depicted so vividly in the video clips, or to the novelty of being invited to participate in a learning experiment. Nevertheless, these good kids (according to their English teacher) produced thoughtful writing based on deep and earnest engagement during both lessons.

Data Analysis

We base our review of the learning outcomes on four sources of data from this single trial:

- Students’ scientific accounts.
- Students’ poems.
- The students’ completed surveys about the differences and similarities, benefits and challenges of writing in science and writing poetry.
- Our own reflections and experience of facilitating the trial lesson.

The students’ science and poetry writing was analysed in two stages. The two authors worked independently, comparing and confirming interpretations at the end of each stage. In the first stage, themes in the students’ poems were analysed according to what we considered overlapped and contrasted with the traditional science domain. Examples of overlapping themes were, for example, extinction, behaviour, appearance, and adaptation. Themes that contrasted with traditional science were, for example, emotion, wonder, faith, and beauty. The predominant themes in their science writing were about behaviour, needs, and facts. In the second stage of data analysis, students' responses to the in-class surveys about their science and poetry writing themes were categorised.

Students' science writing

The students' scientific writing generally described the animals' behaviour and the surrounding habitat and vegetation. They noted assumptions about adaptive strategies based on the animal activity they saw (e.g., "the elephant sprays itself with water to cool it down," "wild dogs use their surrounding[s] to an advantage. They are good in hunting strategy . . . seen through them hunting in packs"). Many accounts included information from the teacher commentary (e.g., about the difference between black and white rhino cow and calf behaviour).

Students' poems

Similarly, many of the poems described animal interactions and behaviour, with a few poems focussing on details of animals' appearance and habitat. Unsurprisingly, given the scenario presented to the students, pervasive themes in most of the poems were about environmental issues of conservation, the human impact on habitat, and threats of extinction.

Students' views on the sorts of things their poems and their science writing said about animals and nature

There were interesting overlaps and contrasts in students' answers. Themes that they noted in their poetry, such as extinction, camouflage, adaptation, animal behaviour, and animal appearance, overlapped with the traditional science domain. Similarly, their science writing represented the traditional the science domain: as they noted, it described animal behaviour—"the facts" and the "main things" about the animals and their environment. Other aspects that the students noted that their poetry and science writing was about, that contrasted, we thought, with traditional views of the science domain were "beauty in nature," "emotions about animals," animal "fun," "God's blessing," and the "wonder and simplicity of nature."

Students' views on differences between science and poetry writing

There were clear divisions in the differences students observed. While they saw their science writing as "factual," "structured," and for "information provision," their poems (they said) contained feeling, emotion, expressed their own opinions and perspectives, and were more personal.

Some students described differences between their poetry and science writing that we find problematic. For example, some noted that their poetry was "creative" where one could be "more open-minded," while science writing was more "detailed"; that poetry writing was more emotive, descriptive, and about one's thoughts, while science writing was, to them, clear, informative, and about "things that were considered more important." Given more time, we would have explored these differences further with the students.

Students' views on writing poems and science reports together

Asked what students thought about writing scientifically and poetically together, five of the nine students were positive, stating that it would be "cool," "enjoyable," and "interesting"—that both kinds of writing told a story but from different perspectives, leading to better understanding. As two students agreed:

That would be quite cool, putting science and poetry together. You can put the facts and what you feel together.

Both a science report and a poem can tell a story . . . a different story but a story.

Three of the students were neutral, thinking that it could be "challenging" because, for example, the two types of writing were "different and required different thoughts."

One student was more negative about combining the two, expecting that it would be "difficult": "A science report is factual so you would have to make your poem factual but it would be a creative way to make a science report."

Interestingly, many of the students described their poems as being about "hidden" things such as "gifts from God," "emotion," the bigger picture of trends in extinction, about "things that aren't what they seem." Science writing was, to them, more about observable, apparent, external things, "what you see." It is tempting to speculate that these comments might reflect the students' emerging awareness of the subjective and objective orientations that exist across the different learning areas of the curricula they encounter, of the varied terrain they must traverse when they discover the nature and substance of disciplinary knowledge and boundaries. In our postmodern era that demands relevant curricula, we need to support more fluent student learning across traditional disciplinary boundaries. Perhaps some students did make small literal steps (pun intended) towards seeing poetic and scientific writing as allies when trying to write (say) about what they really saw (meant). But we can only suggest ideas to be verified in a future more robust trial.

Two further important considerations for further classroom trials of this integrative writing exercise are:

- To allow much more time than we originally anticipated for student immersion, acquaintance, reflection, iteration, and dwelling with the subject or topic in focus, and
- That students' flow of awareness, perception, observation, discovery, and vision must not be impeded by "How do I write this?" A team-teaching approach to helping the students with the techniques of science and poetry writing would be beneficial.

Possible Future Directions for This Research

We are encouraged by the fact that these 15- and 16-year-old students apparently found this exploratory exercise in curriculum reintegration meaningful and productive, despite the specialisation and fragmentation of knowledge in secondary schooling in South Africa and elsewhere. While our claims can only be seen in the context of this introductory study, we aim to collect further data prompted by questions in four areas:

- How might students' written poetry and science responses be enriched if more prolonged and iterative observations of living things in natural settings were possible? Might the repeated act of written expression feed back into developing finer observation skills or more nuanced and subtle perceptions?
- What, specifically, are the types of synergies that might occur when students are challenged to think and write concurrently in both poetic and scientific modes?
- Encouraging students to explore the nature of science and the nature of poetry are now well established as central issues in many national curricula in science (for

example, Bull, Joyce, Spiller, & Hipkins, 2010; Lederman, 2007; McComas, 1998) and in literacy (for example, Dymoke, Barrs, Lambirth, & Wilson, 2015; Locke, 1998; Steinbergh, 1994). Might the processes of student reflection encouraged in the present study generate advances in student notions in both these areas? If so, could this exposure to the epistemologies of science and poetry promote a deepening understanding of the powerful role of education in social change?

- Might the theorising in the present study—that is, the connections between perception, observation, vision, and expression—be helpfully expressed as a generalised model that could inform pedagogical practice across disciplines, and to address challenges in (linguistic and discipline-specific) language learning?

We look forward to dialogue on these issues.

Epilogue

We know it is a huge leap from this single lesson, to the widest purposes of education; from exploring the bases of creativity in the sciences and the arts within the sociocultural frame of classroom learning, to addressing the challenges of social change across countries of diverse cultural and educational norms, but we would certainly concur with Midgley (2001, p. 22) that “the idea that science is a separate domain, irrelevant to the arts, has often produced a strange kind of apartheid” in education generally. Indeed, we cannot help but see this rich classroom experience in the context of a quotation from Richard Holmes’ book, *The Age of Wonder*:

> *The old rigid debates and boundaries—science versus religion, science versus the arts, science versus traditional ethics—are no longer enough. We should be impatient with them. We need a wider, more generous, more imaginative perspective. Above all, perhaps, we need the three things that a science culture can sustain: the sense of individual wonder, the power of hope, and the vivid but questing belief in a future for the globe. (2011, p. 469)*

Finally, a confession

We confess to pangs of self-indulgence as we have been carrying out this research. To systematically bring poets’ gems inspired by the natural world to bear on science learning has seemed so deliciously liberating that something must be wrong.[4] See, for example, James K. Baxter’s (1974) delightful *The Tree House*. But, perhaps, if quality science learning were thought of as perpetual self-indulgence, that would be no bad thing.

Endnotes

[1] See, for example, *Poetry of Science: Richard Dawkins and Neil deGrasse Tyson*, (http://www.youtube.com/watch?v=9RExQFZzHXQ) and *Symphony of Science: The Poetry of Reality—An Anthem for Science* (http://www.youtube.com/watch?v=9Cd36WJ79z4).

[2] Metaphor is, of course, a pivotal creative device for establishing these links, likenesses, and hidden patterns because metaphors are “pervasive in everyday life, not just in language but in thought and action” (Lakoff & Johnson, 2003, p. 3). Indeed, metaphors “guide the way we conceptualise the world” (Hogan, 2003, p. 88). In poetry, metaphors can generate a direct and active imaginative response because they are the most compressed form of image; and because metaphors are unparaphrasable, “an understanding of them depends upon imaging rather than explanation” (Juhasz, 1974, p. 15). In science, fruitful metaphors (often in the guise of mental models) propel further discovery, that is, as Hesse (1972) famously pointed out, there is powerful heuristic value in analysing the way “A is, and is not, B.” As well as in expert science discourse, metaphors are also important in science popularisation (Semino, 2008).

[3] Some people will see resonances here with the work of Californian environmental educator, Joseph Cornell (http://www.sharingnature.com/about-us/joseph-cornell.php) and its resonances in New Zealand (Macfie, 1987, p. 4).

[4] For example, trawling only through the New Zealand and South African literature (the two countries relevant to this paper), there is the work of Louis Johnson, Margaret Mahy, Peter Bland, Dennis Glover (New Zealand); Douglas Livingstone, Guy Butler, Roy Campbell, William Plomer, Dawn Garisch, and Katleho Shoro (South Africa), to name a few. And for learners of a variety of ages, there are all sorts of things waiting in the wings. Do you know Janis Freegard’s (2011) *Kingdom Animalia*, with

its affectionate mocking of Carl Linnaeus: "Carl von Linne woke one morning to the sound of stamens trampling across his pillow" (p. 39). Or, if you venture into science fiction, you may have chortled at Jane Matheson's poem, "An Alien's Notes on First Seeing a Prunus-Plum Tree—This is a device for recycling air" (as quoted in Pirie & Jones, 2009, p. 102).

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