W(h)ither the sense of wonder of pre-service primary teachers’ when teaching science?: A preliminary study of their personal experiences

Tonie L. Stolberg *

School of Education, University of Birmingham, Weoley Park Road, Selly Oak, Birmingham B29 6LL, UK

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This preliminary study seeks to explore whether wonder-based reflections are sources of inspiration for our future teachers of science. What experiences have brought them personally a sense of wonder and when, if at all, do they employ scientific explanations of those events? In all 140 pre-service primary teachers, when questioned, described 240 separate events or occasions in which they had participated or observed that evoked a heightened sense of wonder. Three different types of wonder described all the events cited: physical, personal and metaphysical wonder. Analysis of extended interviews with 15 of the pre-service primary teachers illustrated that such events can transform heuristic responses.

The value of an emotional engagement with scientific processes needs to be recognised, acknowledged and then accommodated within our teaching practices. Teachers of science need to be made aware of a set of emotional cues that they share with their pupils—the ability to give ourselves over to wonder. Not to do this leaves open the possibility that teachers and their pupils will conclude that science is personally meaningless, and unwilling or unable to address issues of personal significance.

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1. Introduction: the role of wonder in science and science education

Why do we teach children about science? In English and Welsh schools science has been a compulsory element of the National Curriculum for almost 20 years. In national economic terms, it is argued that our competitiveness and capacity for innovation depends on our nurturing new talent and developing the science enquiry skills these future science entrepreneurs will need to be engaged and motivated (National Endowment for Science, Technology and the Arts: NESTA, 2005).

But is this all science education should be about: the production of individuals with an interest in, and capable of, practising science? What about the reasons why one would want to become a scientist in the first place? And, if a pupil’s inclinations are not towards becoming a professional scientist, where is the justification for science being meaningful to them? Such cold rationalising is surely not what is going to reverse the trend the NESTA report was commissioned to counteract. Namely, that many British schoolchildren do not want to pursue a scientific career. Popularisers of science, such as Richard Dawkins, have tried to temper the utilitarian approach of policy makers by appealing to their readers’ sense of wonder as they reveal the potential workings of Nature through scientific study and investigations. ‘Of course science pays its way; of course it is useful. But that is not all it is…. Isn’t it a noble, enlightened way of spending our brief time in the sun, to work at understanding the universe and how we have come to wake up in it?’ (Dawkins, 1998, pp. 5–6).

To others, Nature does not speak to us directly, even when our experience is first hand. For Stoneman, the appeal to people’s emotional responses to scientific concerns simply cannot work. This is because of the inaccessibility of most modern science’s explanations and
the processes which need to be studied. ‘To suggest to young students that the study of nature can be successfully achieved through direct observation and intuition is a gross deception’ (Stoneman, 1997, p. 134).

The risk of accepting Stoneman’s approach to science education is that only those individuals who have the good fortune to have gained sufficient scientific training are de facto only able to wonder at and never wonder about the world around them. Why then should pupils ever want to wonder whether the science they are being taught is worth thinking about? For most the choice, as Goodwin points out, ‘is limited to whether they should actively engage with the lesson or mentally go elsewhere. They are required to be present and to do as they are told. Most of them do so, but do they expect to actively make meaning of the science for themselves?’ (Goodwin, 2001, p. 72).

The danger, therefore, is not the relevance of the science curriculum, but that people fail to appreciate the value of expressing views or opinions informed by scientific knowledge and understanding (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2008). As our competence to explore the workings of the computer, the environment or the vaccines we are asked to take declines, so they become, as Appleyard puts it, ‘as irreducible, as absolute, as a natural object … or as ourselves’. And, ‘like a rock or a plant, a part of the natural environment which we pick up in passing and discard when it has expired. It has no interior with which we need to concern ourselves’ (Appleyard, 2004, p. 173).

It is no surprise therefore that both teachers and those they teach may turn to paranormal or anti-scientific explanations for naturally occurring phenomena (Keranto, 2001; Lake, 2005; Rosengren, Johnson, & Harris, 2000; Zeidler, Walker, Ackett, & Simmons, 2002). Nature becomes, once again, comprised of ‘black boxes’, magical and ‘as mysteriously significant as any tribal fetish’ (Appleyard, 2004, p. 173). How then can science educators at one and the same time be reliable, authoritative sources of scientific reasoning and explanations, and yet give their pupils the freedom to develop personally acceptable explanations of the world they inhabit?

2. The nature of wonder—is it more than wondering at nature?

Scientists and philosophers of science have long appreciated the value of having a developed sense of wonder when trying to understand physical processes (Daston & Park, 1998; Fisher, 1998). Indeed, for many scientists, wonder is inseparable from the study of Nature and its processes (Girod, 2007), and is maintained and needs to be nourished in the young by adults who help them to rediscover the ‘joy, excitement and mystery of the world we live in’ (Carson, 2002, p. 55). It is not, therefore, a passive experiencing of the natural world, but an active engagement with—the first step to explanation—and discovery of its underlying processes (Fisher, 1998, p. 99). This is, of course, what science education purports to be about, but little attention is given to it in pedagogic texts and the corresponding research literature. Only recently, with the resurgence of the creative education agenda and, more pertinently, studies into the role of aesthetic experience in the teaching of science (Girod, 2007; Pugh & Girod, 2007; Wickman, 2006), have researchers begun to formally look at its role in learning science. So, are teachers actually instilling as sense of wonder in their pupils? Can teachers encourage a sense of wonder of the natural world in their pupils if they have not ever experienced it for themselves? Or, more realistically, are teachers aware that they can use such experiences in their teaching?

For Pugh and Girod this may be achieved through fostering the transformative, aesthetic experiences of our students. Whilst they are engaged in the learning of science, they are able to apply what they have learnt in the classroom to situations they face outside, thus changing their perceptions and so increasing their interest in the science they have studied (Pugh & Girod, 2007). Science therefore becomes a means by which individuals can seek answers for themselves (Kozoll & Osborne, 2006), to test their ideas and those of others (Pugh, 2004), to assuage their curiosity (Bruner, 1996; Byman, 2001; Day, 1982; Kashdan, Rose, & Fincham, 2004) and so be the impetus for further learning.

This preliminary study seeks to explore whether wonder-based reflections are sources of inspiration for our future teachers of science. What experiences have made them wonder, and when, if at all, did they employ scientific explanations of those events?

The data used for this paper were gathered as part of a wider survey into the ways pre-service teachers utilise science in their heuristic reasoning and their ability and/or willingness to include a spiritual dimension in their science teaching (Stolberg, 2008a). Differences were found to be neither a reflection of prospective teachers’ formal scientific training nor their personal religious faiths—both factors were found to make little difference. Rather, they were indicative of how their personal conceptual frameworks emanate and influence their teaching approaches (Stolberg, 2007, 2008b). In this and future papers, I hope to elaborate on these studies by trying to articulate how these broad conceptual frameworks manifest themselves in teachers’ own personal experiences and assess what is important in informing their heuristic positions.

3. Sample and procedure

The participants were all volunteers, self-selected after the author advertised the aims and objectives of the project and asked for participants to take part in the study. All participants were graduates undertaking a 1-year postgraduate initial teacher education qualification to teach primary-aged children. The course was based at a large urban university in the culturally diverse English West Midlands, where the author is a teacher educator. No incentives were offered to encourage student participation, and all questionnaires and interviews were undertaken outside normal class hours. Questionnaires and interviews were administered at the end of the course’s
first semester, during which participants had already observed and taught a limited number of science classes in local primary schools.

The participant sample reflected the make-up of people undertaking primary initial teacher education at this institution. In all, 140 (out of 154) trainees agreed to take part in the study and completed an anonymous questionnaire. Ten were male and 130 were female. Of the respondents, 34 had undertaken a higher-level course in science, achieving a post-16 level qualification whilst at secondary school, and 25 of the trainees had studied science, or a scientifically related subject at degree level.

Semi-structured interviews were conducted with 15 female students who had completed the questionnaire, and had identified themselves and their willingness to be interviewed. Although two of the 10 male trainees who took part in the study initially indicated a willingness to be interviewed, both eventually declined to give interviews when again asked by the author to take part. Three of the interviewees indicate having studied science to a higher level than that required for entry onto the initial teacher education programme.

The interviews were conducted individually by the author; every interviewee was sent the questions in advance and had a minimum of 2 weeks to study the questions before being interviewed. Approval was obtained before audio-recording of the interview was begun. It was made clear to the interviewees at the start of the interview that they need only respond if they wished to do so, and that they may, at any time, clarify points they have made or conclude the interview. Confidentiality and anonymity were emphasised, and it was explained that pseudonyms would be used in reports of the research. All the interviews were recorded and, at a later date, transcribed.

4. Analysis: identifying different types of wonder

The part of the questionnaire relevant to this paper asked participants if they could describe any events or occasions in which they had participated or observed that evoked a heightened sense of wonder and, if that occurred, what was the impact of the wonder experienced? Participants were also asked whether a scientific appreciation of the event(s) enhanced or diminished the sense of wonder or had no effect. Interviewees were then asked to talk in more detail about the individual events mentioned in their questionnaire responses. Specifically, interviewees were asked to give a context to the events described and to recall any experiential responses at the time of the event or after. Interviewees were also asked to expand on their view of the role scientific appreciation might or might not play in their engagement with the events described.

In total 204 events were described. Most (66%) of the respondents described only one or two events, 27% described three or more and 7% of respondents declined to describe any event. As there was often a clear overlap in the types of event cited by different participants, they were then sorted to see if there were any obvious groupings. On initial inspection, the events appeared to clearly be delineated by the event’s source, i.e. whether it occurred in the natural world, such as a rainbow or a scenic view, or whether it was the product of human endeavour, such as a building or a performance (fireworks display, musical concert). However, on a closer examination of the way superficially similar events (e.g. ‘looking at mountains’ and ‘a visit to the Grand Canyon’) were discussed, such cursory groupings did not reflect the qualitatively different senses of wonder described and their impact on the individuals concerned. Consequently, definitions of different types of wonder were devised to code the events. The veracity of the definitions was checked by comparing the author’s assigning of the events to the pilot definitions to those of a colleague. A further iteration in the definitions was required to code a small number of ambiguous examples. The veracity of these final definitions and the author’s coding of the events were again compared—this time to those obtained by another, different colleague. The three different types of wonder that described all the events cited were:

1. Physical wonder, which is prompted when interactions with objects, phenomena or processes found in Nature are the stimuli.
2. Personal wonder, which is prompted when interactions with human beings or their work are the stimuli.
3. Metaphysical wonder, which is prompted by any type of interaction, but the wonder evoked goes beyond a reflection on the original stimulus.

Table 1 shows the number of events for each defined type of wonder, and whether a scientific appreciation of the event enhanced, diminished or had no effect. Pearson chi-squared analysis shows that there is a significant skewering of events for those that are defined as physical wonder compared to those that are enhanced by a scientific appreciation ($\chi^2 = 13.1, df = 4, p = 0.01$); those events defined as personal or metaphysical wonder show no such influence of scientific appreciation. When the data were further sub-divided to factor in the participant’s gender or level of formal scientific qualification, no significant correlations were observed.

<table>
<thead>
<tr>
<th>Appreciation of the science</th>
<th>Type of wonder</th>
<th>Total</th>
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<tbody>
<tr>
<td></td>
<td>Physical</td>
<td>Personal</td>
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<tr>
<td>Enhances the wonder</td>
<td>17</td>
<td>10</td>
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<tr>
<td>Has no effect</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>Diminishes the wonder</td>
<td>54</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>93</td>
<td>33</td>
</tr>
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4.1. Physical wonder

The most quoted type of wonder, physical wonder, accounts for 46% of the events described. Physical wonder is induced by Goodwin’s wondering at the world around us (Goodwin, 2001), such as ‘the sky at sunset’, ‘a vivid rainbow’ or a ‘visit to the Grand Canyon’ and is wonder at the ‘mere’ physical experience happening at the time.

For Brenda, her wonder at the Cumbrian Lake District illustrates the immediacy of the effect.

BRENDA: This is an example of a magnificent feature in the Universe which you just look at and go, wow! It’s an excitement that you feel—the pulse starts to race!

Brenda’s aesthetic experience produces a physical reaction. It is not just the memory of a beautiful scene, but the response to the event which becomes memorable and meaningful (Fisher, 1998). For many, like Karen, Lesley and Una, an appreciation of the science underpinning the physical process enhanced what was being explored.

KAREN: The trip to the mountain top was very beautiful. We saw glacial pools. I always remember looking down, and, wow, realising that we’ve walked all the way up! Look how beautiful everything is—crystal clear water, wow! Knowing all the processes that went on, the geological terms for everything and trying to imagine the glaciers when they were there, what they did and how it all worked and how long it took! The wonderment of all of that, that nature can do that to a landscape and make it so beautiful.

UNA: The science enhanced the experience because—if you were just looking at it, a bit of lava down there, without understanding where it was coming from and the potential disruption of a volcano—it gave a bigger picture, it wouldn’t have been as big an event.

LESLEY: I remember, by accident, catching a partial lunar eclipse. I can remember looking outside and seeing that the Moon had gone a very strange colour and just standing and standing there. The realisation of what was happening, and particularly the personal discovery, brings with it the wonderment.

This, however, does not mean that all events demand a scientific explanation. The explanation was sought if often described in more personal language.

MIRANDA: To me admiring a beautiful sunset is an aesthetic experience... I want to experience it purely as a ‘being of the moment’...—special to me, to admire as part of my life.

Yet Miranda’s response illustrates another important aspect of our intellectual engagement with wonder; namely, our need to accommodate such events within our own personal narratives and make them, in Miranda’s words, ‘special to me’. It is only then that the individual moves from the passive viewer of beauty to being an active admirer of the event. The event becomes meaningful and requires an explanation. Here is the Socratic notion of philosophy beginning in wonder—knowing one’s ignorance, knowing what one does not know—driving and sustaining the individual’s need to seek intelligibility (Fisher, 1998, pp. 9–10).

4.2. Personal wonder

This type of wonder accounts for only 16% of the events described. These are personal, even intimate events that occur in an individual’s life history but are also shared: social occasions such as the birth of a child or a funeral. Or they are experiences available to many, such as visiting a cathedral, riding a rollercoaster or watching fireworks. Danielle’s description of a visit to Machu Pichu in Peru and Lena’s experience at watching her child grow up are illustrative of this type of wondering at their experiences:

DANIELLE: Machu Pichu is so different from anywhere else I’d ever been—it felt really special to be there, even though there were lots of other people. I felt really special and quiet. You think of the people that made it and how amazing that they were able to do that so long ago.

LENA: I think it is amazing process and the development they go through... This is an experience I’m able to watch at home, watching his development as he changes.

For Danielle, the fact that she also had an understanding of the archaeological significance of the site contributed to a more profound experience:

DANIELLE: The kind of wonderment you have as a child is very different as an adult. Going to Machu Pichu as a child, I don't think I would have found that particularly amazing at all. It would have been like, here are some old buildings and grass and stuff, ... knowing what kind of places they are and the history behind them, helped to picture what the people might have been like.

Danielle’s comments highlight one of wonder’s paradoxes; namely, that the decay in our appreciation of wonder with age is matched by our increasing knowledge and understanding of the very events being observed (Fisher, 1998, pp. 55–56). Wonder is most likely to appear to the young when experiences are limited or little thought has been given over to a particular issue. It is, however, only with experience (such as Danielle’s archaeological appreciation) that we are able to recognise the significance of an event and its relationship to the others things we know. The teacher’s role is therefore to enable their pupils to use the wondrous to reassess what they know, don’t know or is unknowable. Experience does not need to be unique to the individual. Since the wonder is new to the individual, it is new per se.

4.3. Metaphysical wonder

Metaphysical wonder is the second most described type, accounting for 38% of all descriptions. There appears to be no restriction on the type of event that could be the stimulus for this type of wonder. What appears to be
qualitatively different from physical and personal wonder is the nature of the impact the occurrence has on the participant. Metaphysical wonder appears to lead to a shift in perspective as one partakes in a broader reflection on the experience, to its integration with other experiences, leading the individual to ask more searching types of questions.

On the occasions when participants indicated that a scientific appreciation enhanced their sense of wonder, the questions evoked by the event went far beyond the event being experienced in terms of its remit and complexity. For example, Shirley's reaction to flying clearly shows how metaphysical wonder might lead to ask oneself more fundamental questions:

SHIRLEY: Going up in the plane I could see all the science behind the clouds and how they're formed and looking down at the ground and thinking how has the Earth been formed and created and how is it sustaining itself?

Or, in Barbara or Lucy's cases, existential questions:

BARBARA: When I was younger I was quite scared about the origins of the Universe, that there was this big void out there, and it was more of a comfort to think that it was created by God ... I've developed into more of a scientist, with more of a scientific view on things and that it is amazing that over the centuries the world has created—out of itself—something as fantastic as that.

LUCY: You can read and hear about them, but you only appreciate it when you see it take place—particularly a solar eclipse or the Boxing Day tsunami. They are so enormous in their scale, but at the same time almost invisible, because you don't know they're occurring until they actually happen, perhaps with no warning .... You visualise that these things are an inch big because that's what they look like in the sky, so the vastness as you understand the scale and proportions of what is happening is just amazing.

There were also participants for whom the wonder described was indicative of the far-reaching effect the event had had on their lives. Here we move beyond an emotional response to an external stimulus, to the realisation that the event lived through was life changing. The wonder is imbued with an enduring meaning for the individual and, consequently, has the power to transform their heuristic reasoning (Kozoll & Osborne, 2006).

SHIRLEY: My confirmation is more like a personal belief. It was so personal to me and made me grow more as a person spiritually. I had been thinking about it for a long time and had been building up to it.

LENA: My relationship, both physical and spiritual, with my partner is about a life-long commitment and that connection you have with another human being who you meet along the way in life. I think that is an amazing thing! Wonderment is probably not a word I would use, but what I understand by that I can relate to these experiences.

Some of the participants, as Shirley and Lena do above, describe such wonder as a spiritual experience which has little or no overlap with their scientific worldview. There are, however, those participants who do accept that scientific explanations should also be included in their epistemological framework and that scientific study is a perfectly valid path to personally meaningful explanations. They are, in Stolberg's recent findings, using their scientific knowledge as part of an 'epistemic' framework to inform their heuristic responses (Stolberg, 2007, 2008b). The wonder is therefore transformative, able to affect their scientific understanding of themselves and the world they inhabit (Pugh & Girod, 2007; Stolberg, 2008a).

Here are two examples: firstly, Karen appears to 'need' science to deliver a plausible explanation for one person's love for another, what would be for others an unnecessary intrusion.

KAREN: I'm a scientist, I know its all to do with these different endorphins, but it's also quite amazing that one person can make me feel like that but someone else doesn't, so I think there's also something else going on. I'd look to really study it, I know you can't, but when two people fall in love, I'd love them to have all the sensors on them and find out what is going on!

The second example is also describing a very personal event. Here Una reflects on her experience of pregnancy and childbirth.

UNA: As a parent to be, you read up all the books to try and keep up with what's going on with your body and then out comes this other person—it's such an incredible and miraculous, well not really, thing. Understanding how much needs to come together and for the baby to come out and be this perfect little person—the level of complexity is mind-boggling—made a difference to the experience.

Author: Why did you correct yourself when you said 'miraculous'?

Una: On the one hand you could say it was a miracle that it all came together and it happened—no miscarriage—there is that sense of wonderment—wow, did we really do that, that's amazing! But on the other it is the most natural thing in the world—it is just very natural—it couldn't really be any other way. So it's natural and at the same time very special, personal and unique to you, though you know that millions of women have gone through exactly the same experience and you feel connected—part of this bigger picture.

As Fisher has found, both aesthetic and scientific wonder require that 'we find a horizon of the unknown but knowable' (Fisher, 1998, p. 147)—Una's 'bigger picture'. The very act of trying to explain the wondrous forces the individual to revise and reorder the way they make sense of their everyday world. 'The ordinary world means, in the ordinary world means, in the ordinary world means...'

LENA: My relationship, both physical and spiritual, with my partner is about a life-long commitment and that connection you have with another human being who you meet along the way in life. I think that is an amazing thing! Wonderment is probably not a word I would use, but what I understand by that I can relate to these experiences.

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a place for it, we do not fit it in somewhere, but find ourselves forced to undermine the nature of place altogether in order to lift many other things out of their places in order to make sense of this one’ (Fisher, 1998, p. 101).

Is it reasonable to ask teachers to help their pupils to appreciate scientific phenomena so that it evokes transformative wonder, wonder that has an enduring effect and is personally meaningful so that it transforms the way one makes sense of the world? Can this be a realistic goal of science education? For some, science education would be for naught if it was not:

‘The feeling of awed wonder that science can give us is one of the highest experiences of which the human psyche is capable. It is a deep aesthetic passion to rank with the finest that music and poetry can deliver. It is truly one of the things that makes life worth living’ (Dawkins, 1998, p. xii).

How can the educationalist best respond to Dawkins’ impassioned plea? To turn it into a question that may be more easily addressed here, do teachers of science have the ‘aesthetic passion’ to inspire their pupils to wonder as Dawkins would like us all to do?

5. Conclusions and implications for the teaching of science: making science teaching more meaningful

Is this an achievable goal for all teachers? For some, Karen for instance, the passion is already there:

KAREN: I knew that you could combine coloured lights to make white light, but I’d never actually seen it happen before until we did it in class, and I thought, that is so cool! I’d love to do that with the kids one day—put them all together and show them that we can make white. It’s such a weird concept! To know that it happens and then see it happen—I still can’t quite get my head round how it works!

For those who view science as a ‘pragmatic’ tool, useful, but of little personal significance, wonder is something one outgrows (Stolberg, 2007). It is part of being a child and not a thing a rational adult is supposed to do—it would not occur to them, as a teacher, to encourage it in their pupils!

DANIELLE: I first saw thunder and lightning when I was little, and it seemed amazing what was going on—when you’re little, you create little stories about what is happening. Later on, when you’re older and you find out about it this lessens the wonder because you’re not wondering anymore, you know that’s why it does that, whereas before you don’t know and that makes it more fascinating.

AUTHOR: Is wonder linked to a lack of knowledge?
DANIELLE: To some degree, it’s certainly an aspect but not everything.
WHITNEY: The reason I didn’t put down any events is because I wouldn’t describe anything as having ‘wonder’. You might think something like the birth of my cousin might, but for me there wasn’t any wonder in it. It’s lovely, but you know what happens, it’s natural and it’s normal. Wonder is what I connect with something fantastical and not normal—something spiritual which I don’t think I am.

Danielle and Whitney’s views misunderstand the pedagogical imperative of allowing wonder to affect our heuristic approach to the teaching of science, and for most of the pre-service teachers participating in this research, science is not where they turn to find meaning for wonder evoked. For many of the lived experiences described, scientific reasoning is at best unnecessary, or, at worst, an intrusion. Science is somehow perceived as being at odds with what is of personal importance; it explains everything, apart from what we want to really know about—ourselves (Appleyard, 2004, p. 205). Its perceived purity, logic and amorality denude it of those very human characteristics that helps us to give meaning to our lives and actions (Fulljames & Stolberg, 2000; Fysh & Lucas, 1998; Jackson, Doster, Meadows, & Wood, 1995; Loving & Foster, 2000; Nyhof-Young, 2000; Petersen, 1997; Stolberg & Fulljames, 2003).

Many rationalists would wish this divide to be maintained and even emphasised, as it is the ‘delusions’ of religio-cultural societies that stop human beings from developing a more realistic meaning for their lives (Dawkins, 2006; Dennett, 2006). A quotation from an earlier work of Dawkins makes the same case: ‘The mystic is content to bask in the wonder and revel in a mystery that we were not ‘meant’ to understand. The scientist feels the same wonder but is restless, not content; recognises the mystery as profound, then adds, “But we’re working on it”’ (Dawkins, 1998, p. 17).

What is agreed by all, whether they are rationalist, spiritualist or theist, is that, for a working heuristic appreciation, the experiential realities that shape our everyday lives are important, need to be explained and should not be ignored. For science educators, it is the value of an emotional engagement with scientific processes that needs to be recognised, acknowledged and then accommodated within our teaching practices (Zembylas, 2007). Not to do this leaves open the possibility that teachers and their pupils will conclude that science is personally meaningless, and unwilling or unable to address issues of personal significance. For science to be enabled to do this, our teachers of science already have a pedagogic tool at their disposal, a set of emotional cues that they share with their pupils—the ability to give ourselves over to wonder (Sheets-Johnstone, 1999, p. 336), rather than be mere momentary observers of a phenomena or event. This is, of course, a preliminary study; however, it is clear that both teachers and pupils need to be made more aware of the feelings wonder can engender. Pedagogical strategies need to be developed so that teachers can facilitate pupils to reflect on the possible meanings of the wonder, so helping them to develop a mature ‘scientific voice’ (Stolberg, 2008a)—the articulation of a view of science that is both personally meaningful but also accurately reflects the spirit of its endeavour. Thus, pupils are given the opportunity to live with the wonder long enough for it
to become theirs and be transformed by it. Here is a way to help our pupils to change into critical thinkers who develop those capacities so valued for scientific exploration, to reason and to perceive connections, consequences, inconsistencies and flaws (Sheets-Johnstone, 1999, p. 339) to give them the reasons for wanting to study science and, perhaps, become a scientist. In short, to make science a natural part of the way you make sense of yourself and the world around you.

References

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References


