

Recognizing the Beauty: Aesthetics in Science Teacher Education

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Beauty and the Nature of Science

Sometimes nature appears to us as beautiful. Speculation on the source of this sense of beauty is the philosophy of *aesthetics* (Greek, *aisthetikos*, “to perceive by the senses”). Plato believed that pure ideals of beauty existed with the Gods and was represented in nature and through human creative acts (Sartwell, 2014). In a similar way, the great monotheistic faiths of Judaism, Christianity and Islam locate beauty in the mind of God, supposing that humans, made in the image of God, have the ability to replicate aspects of beauty through creativity; for example by building structurally-symmetrical architecture such as the Eiffel Tower or more traditionally through the visual and musical arts. A similar view of beauty pervades traditional Asian cultures, where the Chinese character for “beauty” (měi) is included in the two-character symbol for, “perfection” (wan měi).

Aristotle considered beauty to be an essential aspect of Nature itself; he called the human ability to discover this beauty *aesthetics*. A good example of what he considered evidence of beauty is the widespread appearance of the Fibonacci sequence in the spiral patterns of shells, flowers, and even the human outer ear (Armstrong, 2009). Kant argued a

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more etymologically accurate view of aesthetics² by arguing that what we consider beautiful is not the world *per se* but our subjective interpretation of the world, which is, of course, influenced by an individual's culture and life experience (Sartwell, 2014). The problem of this more relativistic view of aesthetics is that some experiences, such as those of a vivid sunset, seem to be *universally* appreciated as beautiful. Hegel sought to resolve this issue by suggesting that nature *can be* beautiful in itself but the sense of beauty, our aesthetic sensibility, results from a dialogical process of understanding what nature presents us through our senses and our life experiences.

Hegel's perspective on beauty as a dialogic experience of nature is reflected in the writings of many famous scientists. The great botanist Joseph Paxton described botany as the "science of beauty" (Paxton, 1838, ix). In his study of glaciers, the scientist John Tyndall wrote that nature is a "prodigal of beauty" (Tyndall, 1911, p. 247). Cosmologist Carl Sagan, recalling the first time he read that stars were giant balls of fire, remembers feeling that "there was something beautiful about it" (Sagan, quoted in Head, 2006, p. x). In his book defending science, *The Demon Haunted World* (1995), Sagan writes that, "in its encounter with Nature, science invariably elicits a sense of reverence and awe" (p. 29). The great physicist Werner Heisenberg, in a letter to Albert Einstein, suggests that there is an "aesthetic criteria of truth" in science captured in "the simplicity and beauty of mathematical schemes which nature presents us" (As quoted in Stewart, 2006, p. 278). Einstein would have agreed, famously describing science as an experience of the "mystical... of wonder, standing rapt in awe" (As quoted in Frank, 1947, section 5).

² Immanuel Kant used the word, "aesthetics" in the classically correct sense as, "the science that examines the conditions of sensuous perception."

But Hegel's views of aesthetics invite us to take further the appreciation of Nature that seems fundamental to science. Rejecting a universal definition of beauty, Hegel argues that true beauty emerges not in the apprehensions of the senses but through the *expression* of this sensual experience; he believed that such expressions are ultimately attempts to understand self and called these expressions, "art." Aesthetics in science, then, from a Hegelian perspective, would move from engagement with nature and reporting this engagement through words, formulae, and graphs towards *expressing* this engagement *artistically*. Hegel suggests such a possibility in his comment that art is part of the reflexivity of experience, a "supra-sensuous" experience that, according to Hegel, brings us "nearer to the senses, to feeling and to nature's mode of appearance" (Hegel, p. 1886). Seen this way, art as expression is a way to *understand* our sensual experiences of nature and through artistic creation we discover ourselves; when this happens, argues Hegel, we truly experience *beauty* (see Houlgate, 2014). The opportunity to experience beauty as an aesthetic of nature suggests a possible method for fostering a deeper understanding of the nature of science with pre-service science teachers.

The Nature of Science and the Education of Pre-Service Teachers

In their 1985 world survey of studies of public attitudes towards science 1985 the Royal Society of the United Kingdom concluded that, "evidence unanimously argued, in a variety of different ways, that public *understanding of science* was inadequate" with, "much less understanding of the nature of scientific activity than knowledge of scientific facts" (p. 15, emphasis in text). Little has changed since this study. For example, the annual U.S. National Science Foundation *Science and Engineering Reports* indicate that over the past 15 years

American understanding of the process and role of science has *decreased* (National Science Foundation, 2014).

Sagan (1995) considers the general public lack of knowledge about science and technology a social “disaster” arguing that,

We’ve arranged a global civilization in which most crucial elements—transportation, communications, and all other industries; agriculture, medicine, education, entertainment, protecting the environment, and even the key democratic institutions of voting—profoundly depend on science and technology. (p. 26)

It is clear that understanding the role, nature and activity of science is vital in an age when many if not most of the issues facing humankind require a public informed by and about science (Alters, 1997; Duschl, 1990; Lederman, 2007). This understanding begins with school science educators. Matthews (1994) considers teaching the NOS to be *the* goal of school science education; every science educator agrees that teaching students to understand the NOS is an essential element of a school science education programme.

Locating responsibility for teaching the NOS in school science education presents a dilemma: How can science teachers teach the NOS when science teachers themselves often have a poor understanding of the nature of science? Lederman (1992) succinctly notes in his review of assessments of science teachers understanding of the NOS, that “teachers of science, in general, do not possess adequate conceptions of the nature of science” (p. 341). One result of this lack of understanding is that teachers assume positivist, realist and incomplete views of science (Abell and Smith, 2007; Meichtry, 1998) that is subsequently reproduced in students through a pedagogy that reduces science to an authoritarian collection of “facts” that must be memorized for tests.

Pre-service teacher education presents an opportunity to break this cycle. But typically courses in science education pedagogy are at best 35-40 hours of instructional

time. Despite this brevity, many teaching science education courses plan experiences where students directly examine the nature of science, typically through studies of argumentation, research into the history and philosophy of science, or by attempting to understand the NOS through actual experimentation (Nott and Wellington, 1998). Such activities, however, seem to have a limited effect in helping pre-service teachers actually understand the depth and nature of science (Bell, Lederman and Abd-El-Khalick, 2000); Kim, Anthony and Blades, 2014; Woolnough, 2014).

Introducing the Aesthetics of Nature in Pre-Service Science Teacher Education

In her last work, biologist Rachael Carson (1998) observed that, “a child’s world is fresh and beautiful, full of wonder and excitement. It is our misfortune that for most of us that clear-eyed vision, that true instinct for what is beautiful and awe-inspiring, is lost before we reach adulthood” (p. 54). To prevent this erosion of wonder, she believes the child needs “at least one adult who can share it [wonder], rediscovering with him [or her] the joy, excitement and mystery of the world we live in” (p. 55). Hegel’s view of aesthetics suggested that inviting students to explore nature and then express this exploration through some form of creative arts, such as poetry, music, narrative writing or visual arts, could develop a deeper understanding of the nature of science.

I decided to try incorporating Carson’s advice in my pre-service teacher education course on methods of teaching children science. I invited students in the classes for elementary school science education (n = 41³) and those classes for teaching science in

³ This is the number who agreed to participate (85%) in the research about this assignment.

secondary schools (n = 18) to participate in a new assignment, which I called the “Aesthetics of Science.” Students were asked to:

1. Choose a “part of nature” to study.
2. Research the “science behind the nature” chosen.
3. Prepare an aesthetic expression of their discovery. The choice of media was up to the student. *This expression was not evaluated.*
4. Reflect on the implications of this discovery for teaching children science, including if they would change at all a class-generated definition of science.

Since this assignment was fairly challenging and, in the spirit of sharing my personal excitement and wonder of Nature, *I did the assignment myself* and then shared with the students my expression of my understanding, which in this case became a poem. Based on comments on the course evaluations, this demonstration served as important

encouragement for the students.

Assignment submissions exceeded my expectations; none adopted anthropomorphic or romantic views of nature and 80% of the pre-service teachers developed a deeper, clearer understanding of the NOS.

The topics explored by students were quite varied, but most examined large, dramatic natural events, such as rainbows, sunrises/sunsets, cloud formations, shooting stars, and changing colour of leaves in the fall. But some students ventured wide in their explorations and I had submissions that

Figure 1. Jessica’s aesthetic expression of her study of dreams. Notice how, in this collage, dreams carry one away over rooftops—a kind of liberation—a “movement away from reality” but that one balloon is escaping, representing dreams that seem to also have a life and direction of their own. The girl depicted in the collage is any person, her joy as she “experiences deeply embedded emotions” while dreaming.



included studies of rusting, bioluminescence, eye colour variation, dreams, tattooing, turbulence in sand, DNA replication, the nature of love, and human-dolphin interactions.

Despite Hegel's argument that aesthetics opens up understanding, I was concerned that this assignment might be the case for only two of the 59 teacher candidates; the vast majority (97%) found learning the aesthetics of science assignment *enhanced* their appreciation of nature. Kaitlyn⁴ felt that: "This assignment helped me see mysterious,

Figure 2: Rachel's expression of her study of shooting stars:



exciting, and beautiful." Tanya found that, "it [lightning] was terrifying, awe inspiring and beautiful. It was sublime." Laura expressed how she was "overwhelmed by the beauty" of what she studied. With most students, this assignment *expanded* their view of Nature. Hailey discovered that, "perhaps we see through a narrow lens what something is, when really it is so much more." Rachel observed that, "I thought it would make me sad and it would ruin

this whole notion I have held most of my life, but this is not the case. There is something beautiful about all this..." From her study of shooting stars she felt

such an excitement and chaos inside myself...to think that all of this is happening up in space, every day, is unbelievable. In fact, it is quite difficult to wrap one's head around this idea...there are so many complex systems and processes happening in space, all the time, which are so much greater than I think we realize...

⁴ All names used with permission.

Through exploring the idea of something we, individually, find beautiful, we are feeding into our childhood desire for wonder, imagination, exploration, and curiosity that often gets lost in adulthood.

Effects of the Aesthetics Assignment on Understanding the Nature of Science

At the beginning of each course students created a class, “working definition” of science. Those becoming secondary school science teachers defined science as the “dynamic exploration of the cosmos via verifiable evidence-based methods, which stems from curiosity.” Those becoming elementary school teachers defined science as, “an on-going exploration of relationships in the natural world through hypothesizing, observing, theorizing, and experimentation.” Each definition partially reflects the activity and process of modern science. After completion of the aesthetics assignment, *85% of the students changed their class’ definition of science* in ways that reveal a deeper understanding of the NOS.

The most common inclusion by both groups was an additional emphasis on *curiosity*. To these students, curiosity drives the passion to explore in science and therefore is an essential part of any definition of science. These beginning teachers also felt that the development of students’ curiosity is a key goal of science education. Desiree wrote that, “without a purposeful fostering of childlike curiosity, it is almost meaningless for us to try and stand in front of a class and teach them something they truly care very little about.” Stephanie added that, in her opinion, “students have a right to be curious.”

The second common inclusion by both groups was the belief that science should foster a sense of beauty and appreciation for nature. This sentiment is a close alignment with how scientists view their activity as scientists. These pre-service teachers believe that

the pedagogy of beauty is an essential part of science education. Klöe summarized well the views of her peers: “By installing an appreciation of the beauty of science and nature in our students, they will learn to become curious, observant, grateful, and enthusiastic scientists, naturalists, perspective-takers, community members, and explorers of their own natural world.”

The third most common change in the views of the NOS among pre-service teachers was a sense of *responsibility for nature* that, according to these teachers, is part of science. Miranda felt that, “to appreciate the natural world in all its glory will not only foster a life-long curiosity about the world we live in but hopefully also promote an attitude of preservation.” Each student felt that opening students to the beauty of nature was also opening these students to their responsibilities as caretakers of nature. Hailey wrote, “I hope that in opening their eyes to the beauty of all that is around them, they will begin to respect, care for, and feel a sense of responsibility for the preservation of the natural world. As well, I hope it will instill in them a reverence for science that I did not experience as an elementary student.” Krista-Lynn agrees: “I want my students to find the beauty in nature while studying science and I want them to care about what they're studying for its place in nature rather than just the science we can discover from studying it. I want to develop within my students a sense of wonder and respect for nature, so that they can take care in their science studies and daily lives to be good to the world around them.”

While those teachers becoming secondary school teachers focused their changes on their class definition to the additions of curiosity and beauty, there were additional changes among those in the elementary teacher education programmes. In those classes, those changing the class definition of science added that science is an “open-ended” study; that is,

there is no limit to the questions asked in science. Approximately one-third of those in the elementary teacher education programme also reported on an experience which could be described as “touching the *il y a*.”

Il y a and Responsibility

Most of the pre-service teachers in the elementary school teacher education program also discovered that, from their perspective, science is a *personal* study that involves *connection* to what is being studied. Students felt that such connections were essential to enable discovery, drawing on their experience learning about the part of nature they chose to study. This ability to choose a topic of study was seen by participants in this assignment as essential to understanding science. As one pre-service teacher remarked, herself an experienced scientist, “students should be given the freedom to think of their own questions, as this is an essential skill towards thinking like a scientist.”

Approximately one third of those in the elementary teacher education programme shared that their study invoked a sense of awe and a realization of “how small we are” as they reflected on the immensity of the universe. These students were most likely to choose dramatic natural phenomenon, such as lightning, rainbows or sunsets. However, this expression also appeared in studies of slugs, eye color, rusting, ocean waves and dreams. Of the third that expressed awe, approximately one half again experienced something profound as a result of their study. I describe this as a contact with what the philosopher Emmanuel Levinas (2002) calls the, “*il y a*”—the “there is” behind/before being. This touching of the “it” of Nature, as the “it is raining” or, “it is hot today” suggests something deep, raw, almost primal experience of Nature. The philosopher Heidegger (1962)

describes this experience as a “pre-phenomenological glimpse” (p. 103) of the is-ness of the world, which he assumed would invoke feelings of anxiety or fear—as if touching the sheer rawness of Nature would be terrifying. But, in fact, those reporting these experiences *had the exact opposite reaction*. For these pre-service teachers, touching the *il y a* of Nature was a “sublime” experience, an experience of the awesomeness of Nature; *every* student with this experience reported finding nature “beautiful.”

Figure 3. Ashley’s sketch of a tree stump as part of her study of tree rings. She attempts to share her realization that trees “represent wisdom”—so she includes words in between the lines of her sketch, such as “strong,” “traditional,” and “beautiful.” Her study called her to a greater sense of responsibility towards living trees.



These same pre-service teachers, perhaps as a result of this experience, reported a strong sense of *responsibility* for Nature and that development of this responsibility must be an essential part of any science education. Miranda felt that, “to appreciate the natural

world in all its glory will not only foster a life-long curiosity about the world we live in but hopefully also promote an attitude of preservation.” Each of these students felt that opening students to the beauty of the world was also opening these students to their responsibilities as caretakers of the world. Hailey wrote, “I hope that in opening their eyes to the beauty of all that is around them, they will begin to respect, care for, and feel a sense of responsibility for the preservation of the natural world. As well, I hope it will instill in them a reverence for science that I did not experience as an elementary student.” Krista-Lynn agrees: “I want my students to find the beauty in nature while studying science and I want them to care about what they’re studying for its place in nature rather than just the science we can discover from studying it. I want to develop within my students a sense of wonder and respect for nature, so that they can take care in their science studies and daily lives to be good to the world around them.” These results suggest that inviting aesthetics in pre-service courses in science education methodology can be a profound experience of reconnection with their childhood sense of wonder but also presents a potent approach for enabling teacher candidates to understand more fully the nature of science and, in some cases, to develop a greater sense of responsibility for the natural world.

Views of science education

Every pre-service teacher found the aesthetics assignment changed their view of science education and that expressing their journey aesthetically was the key. Those in the secondary teacher education program especially found the artistic requirement difficult at first. Hayley wrote that, “painting is something that I rarely do as I don’t feel I am artistically creative enough. It was interesting and caused me to struggle; trying to

represent something I see everyday as best as possible while having it a bit abstract, which I tried to attempt.” John admitted that, “the act of putting that appreciation into artistic form was supremely difficult...[but doing this does] free us to explore avenues otherwise denied us [in conventional modes of expression in science]. Students in this program generally agreed that depicting their study in the form of art changed their view of science and science education. For example, one student wrote that,

the process of exploring science through artistic expression has triggered a new way of thinking for me. Although I have always been curious about how the world works, I have never considered science to have much place for creativity.

Those in the elementary school teacher education program expressed similar sentiments. Chantal found that, “through this research I now have a deeper understanding that science is all around us.” Brittany wrote: “doing this assignment I was able to reawaken my curiosities.” Heidi discovered that, “science involves some deeper thinking in order to understand it fully.” Klöe summarized the views of her peers well: “this assignment has increased my appreciation of our natural world, how truly remarkable it is and, as a result, I feel increasingly more motivated to help protect it.” Chris summarized the pedagogical realizations that emerged with the pre-service teachers through the aesthetics assignment:

How do we create wonder and mystery of our world? The answer is not so simple. I think that if we ask thought provoking questions, and allow the students to branch

off and explore the world for themselves we might be surprised about how much they can do.

Summary

Scientists often describe their work on understanding nature as encounters with the beautiful. This sense of beauty and wonder in the presence of nature seems a universal human experience that is systematically dampened by a student's experience of school-based education (Robinson, 2006) and especially so, if ironically, in school science education. It is clear that engagement in the issues facing humankind, many the directly caused and affected by scientific and technological innovation, requires a citizenry familiar with the nature and activity of science. This places special demands on science teacher education to enable graduates to understand the nature of science. What may be missing in attempts to foster this understanding is the creativity, curiosity, sense of beauty and wonder and call to responsibility that lies at the heart of science. As Brenda argues in her assignment, "I think that the primary goal in science education should be to get students excited and interested in the natural world by showing them the beauty and wonder that surrounds them."

The research shared in this paper reveals that one successful way to develop students' sense of the nature of science is to invite students to artistic expression of their explorations of nature. Rather than occupy separate spheres of human activity, art seems to be an *essential* part of science, yet is typically missed entirely in a student's science education. Opening science teacher education to the aesthetics of nature and inviting artistic expressions is a powerful way to help these teachers understand science and also

becomes an invocation to responsibility for nature. To secure a hopeful future for humankind, understanding that science involves appreciating the beauty of nature and responsibility for nature may be the most important lesson given by these new teachers to the next generation.

Postscript: The Eiffel Tower

The emphasis on nature for the Aesthetics assignment was promoted, in part, by my example study of snowflakes. However, *every* student followed my example and picked an aspect of nature to study; indeed, an emphasis on choosing an “aspect of nature” to study was how this assignment was first described. One student in the secondary programme, however, chose to study a mathematical expression (Euler’s Identity)⁵ that he (and mathematicians generally agree) found particularly beautiful. His assignment was illuminating and led me to expand the assignment possibilities for subsequent classes to “anything you find beautiful,” which could include human constructions. I have recently turned from snowflakes to a study of the Eiffel Tower, noting that while critics of the time of construction described the tower as a, “truly tragic street lamp” or, according to the famous Protestation des Artistes in 1887, an “ugly tower of Babel,” physicists, engineers and public opinion generally have come to agree with Eiffel that his famous tower possesses “its own beauty.” In response to his critics, Eiffel argued that “is it not true that the very conditions which give strength also conform to the hidden rules of harmony?” (Eiffel, quoted in Tour Eiffel, 2015, p. 1). To this end, and as a result of my journey of discovery of this (to me) beautiful construction, I intend to create a painting that I will

⁵ $e^{i\pi} + 1 = 0$

share with my students in the Fall, 2015 when I describe the Aesthetics Assignment. While I can not predict what effect this will have on the topics students will choose, I do believe that whatever they choose, their study will lead them towards a greater understanding of science and, perhaps in some cases, technology—we shall see.

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