Recovering Beauty Through STEM Science Education: A Letter to a Junior Colleague

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Responses

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ABSTRACT

Although usually a strong critic of STEM, the author of this paper argues that STEM as a curriculum heuristic is not necessarily a delimiting framework. Reviewing the history of acronyms in science education, this paper argues that curriculum organizers represented by acronyms are constantly evolving in science education but the meaning of these acronyms lies in the lived curriculum of teachers and students. An example of infusing STEM with questions about beauty is used to illustrate how teachers with students might undermine and redirect the neo-liberal imperatives of STEM towards a science education for all citizens that enables a healthy, informed, responsible democracy.

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Introduction

The majority of my scholarship during my academic career has involved a relentless critique of technical-rational approaches to curriculum change and, in particular, approaches to change in school science education curricula. From a post-structural perspective, this critique has revealed systemic issues in the current practice of science education and attempts to manage the development and implementation of new school science education programmes (see Blades, 1997, 2001). But as my career continued, I began to be weary of critique and longed, in a truly non-post-structural way, for a more hopeful discourse or, at the least, some advice about how we might still provide for children a relevant, cooperative, ethical and responsible science education experience.

This year (2016) I was awarded a 3M Fellowship, a national honour for excellence in teaching and teaching leadership. One aspect of this honour is a lifetime membership in the Society for Teaching and Learning in Higher Education and an opportunity to travel to the annual conference of this Society to receive the 3M Award, meet other award-winners and generally become involved in discussions around post-secondary education. As a participant of this year’s conference and 3M winner, one of the conference organizers asked me to be part of their “human library” project. Essentially, the project invites conference attendees to “borrow” a 3M Award winner for a 30-minute block of time for a one-on-one conversation about teaching. I volunteered to participate in this project; in anticipation I imagined some of the questions I might be asked, assuming that at least some might be about science education. One of the questions I imagined discussing focused on STEM.

STEM has become ubiquitous in discussions, journal articles and government documents about school and post-secondary science education, even to the point of being synonymous with science education. Previous discussions about STEM with colleagues and students reveal a wide acceptance of this acronym, or at least a lack of fundamental questioning about STEM that might include: What does STEM mean? When did STEM first appear in the discourse of science education? What does STEM represent philosophically? Does STEM actually represent the goals we intend and hope for science education? I began to formulate responses to some of these questions, which led to this essay, presented in the form of a letter from a “more senior” (at least, in age) colleague to a colleague new to the academic life. I imagined this new colleague “borrowing” me for a time and the first question being, “What does STEM mean to you?” The essay below is my response and is offered as an invitation to conversation about the meaning of STEM and some strategies for undermining and reorienting the neo-liberal agenda animating STEM.

Dear Colleague,

Thank you for your email about STEM as an approach to science education. I tried to write a short response, but realized quickly that thinking about STEM requires a sense of the context that gave birth to this acronym and that, as well, there are some important questions to ask about STEM, questions that also relate to our relationships to science curriculum (and, indeed, all curriculum) in general. So, I have attached to my email to you this longer essay in the hope that you and I might engage in a long, deep and continual conversation about STEM and the wider questions about teaching science.

STEM, of course, stands for “science-technology-engineering-mathematics” and implied in this collection of words are relationships. STEM is also a lovely word itself; the acronym evokes trees or bushes, branches and growth, a sense of movement outwards and onwards as we come to think about science in relationship to technology, engineering and mathematics. There is a positive element to STEM, a tone of
promise that if we can somehow incorporate and teach STEM in science education, we will have a science education curriculum that is deep in understanding, practical for employment and essential to innovation.

Acronyms are not new in science education. After the former Soviet Union launched Sputnik in 1957, the United States and Great Britain launched into a wholesale and complete overhaul of science education at the national and state levels. The new programmes, such as the “Biological Sciences Curriculum Study” (BSCS) were typically referenced by academics by their acronyms; some of these new curricula advocated a new, more inquiry-based approach to teaching, such as “Science A Process Approach” (SAPA) and others merged both content and method, such as the Physical Sciences Curriculum Study” (PSCS); in fact, there were so many acronyms of programmes developed from 1960 to the mid-1970s that this time in the history of science education is sometimes called the “alphabet soup science” (Kyle, Shymansky, Alport, 1982). One important feature of all of these programmes was their completely overt, stated goal of creating more scientists and engineers in order to compete against the rising technological development of the Soviet Union and, to a lesser extent, communist China. In this way, science education was used as a form of social engineering to meet a supposed threat of communism—and it is in this sense that STEM has political parallels.

This history is important. I was in high school when the new “alphabet soup” programmes arrived and our teachers did not know what to do with them—most were “teacher-proof” in the sense that teachers simply had to follow the provided lesson plans, use the films and materials that came with the kits and so “implement” the new programmes. But, the programmes arrived precisely at a time when many of my friends (but not me) were deliberately not choosing a career in science and, for most of us, the new programmes made that decision even more obvious. Why? Because the way the new programmes were taught was, to be blunt, boring for many students (see Beardsley, 1992). This is because so much content was stuffed into the programmes that teachers wound up lecturing and, in many regions of the world, worked to help students memorize the content they would need to know for a government-administered final exam. I imagine this was also your experience for part of your science education and it will be the experiences of many of the students you will be teaching as a professor; we have all experienced the legacy of the post-Sputnik reforms and one of the sad consequences of this legacy is a public that was largely turned off from science by their school science experience, with a subsequent drift away from science-related careers, at least in Canada.

But the world changed a lot during the 1970s and 1980s and ironically the new science programmes, which focused on understanding science from the perspectives of scientists, became increasingly irrelevant in the light of the invention of the hydrogen nuclear bomb, civil rights movement, war in Vietnam, evidence of global pollution, rise of AIDS—to name just a few of the social issues not considered at all in school science education. The post-Sputnik programmes were socially-sterile and this no doubt also contributed to what science educator David Stenhouse (1985) famously called the public drift from science. So, many of the generation of academics before you—which includes me—have worked to change science education curriculum from a focus on a career in science to an education for every citizen, a more socially-conscious science education. This movement to reconceptualize science education for citizenship was called, “STS” or STSE” science education; yet another acronym, which in this case stands for an approach to science education that stresses the relationships between science, technology and society, with the later addition of “E,” standing for “environment.” Canada encouraged an STSE approach to school science nationally with the Common Framework for Science Education Outcomes (Council of Ministers of Education of Canada, 1997) and I encourage you to find and examine this important document. Similar adoptions of an STS or STSE approach can be found worldwide, in countries such as the Netherlands, Germany and in several US states.

As you can see, acronyms to describe approaches to science education are a characteristic feature of science education, so the arrival of STEM as the newest acronym is a normal and almost expected part of the evolution of science education. But this does not suggest that STEM is an improvement in science
education; I submit to you that it is not—in present formation and influence, but I also suggest that it could be if we think about curriculum differently and if we learn from the historical antecedents I’ve briefly sketched out.

It is difficult to trace the exact origin of STEM, but working with my colleagues Matthew Weinstein and Shannon Gleason we found that STEM seems to have originated in the mid-1990s in government documents in the United Kingdom in reference to immigration policies; in particular, to some of the science-related occupations where, for a time at least, the UK seemed to be experiencing a shortage for employment. In other words, scientists, engineers, technicians and mathematicians were given special advantage when applying to immigrate to the UK. The acronym SMET (science, mathematics, engineering and technology) is a precursor to STEM and was around in documents concerned with post-secondary job expectations in the four areas by the US National Science Foundation (George et al., 1996); the acronym was reorganized into the now familiar STEM, appearing by 1999 in the US Congressional Research Services paper, Science, Technology, Engineering, and Mathematics (STEM) Education: Background, Federal Policy, and Legislative Action. These documents clearly locate STEM as a conceptual organizer referring to jobs in the areas represented by the acronym. This marks a significant departure from the focus on citizenship that is the defining principle of STSE approaches. Since the year 2000, STEM has grown to define all science education; there are now STEM schools, teacher in-service is on how to teach STEM, professorships in STEM and the American A Framework for K-12 Science Education (Committee on a Conceptual Framework for New K-12 Science Education Standards, 2012) focuses on STEM. STEM seems to be everywhere: This summer (2016), the Leadership Committee for English Education in Quebec is hosting a “STEMPOWER” teachers’ conference as part of the Canada-Wide Science Fair, the US State of California hosts an annual STEM conference and in 2015 the University of British Columbia hosted an International STEM in Education Conference; a quick search of STEM with a Goggle search engine provides 241 million hits, while the 40-year old STSE provides only 11 million hits.

The ubiquitous presence of STEM as a conceptual organizer for science education suggests that STEM has replaced or overwhelmed STSE approaches (and indeed all other approaches) to science education. Yet STEM itself is now 16 years old itself and one might wonder if a new acronym is on the horizon; indeed, there already are those arguing for the addition of the arts to STEM, the so-called “STEAM” approach (Zeidler, 2014; Kim, et al., 2012)—and there could be others possibilities as well, for example, “science and technology for responsible environmentalism and arts in mathematics (STREAM) (I just make this up, but you get the idea). So, the history lesson is that acronyms come and go in science education programme development and new ones are likely to appear during your career.

But, do acronyms matter? I believe they do and that we need to pay attention to the shifts in thinking about the role and activity of school science education represented by curriculum acronyms. It is important to remember that STEM was historically located in trying to promote more youth to consider careers in science, engineering, technology and mathematics. There is nothing wrong with encouraging such careers but a focus on careers creates what Zeidler (2014) calls a “stilted understanding of science literacy”; that is, with STEM as a conceptual organizer, science education becomes a vehicle to serve particular, narrow market demands supposed to exist by government agencies. These demands are particularly focused creating a workforce that can compete with the industrial forces of countries such as China and those in Europe; in other words, the purpose of science education in STEM is reoriented to a neo-liberal free market ideology driven by nationalist rhetoric. This is, of course, a parallel to the raison d’être of the post-Sputnik reforms, except the new “menace” are countries that supposedly have more engineers, scientists, mathematicians and ability in technological innovation; in short, STEM is the newest use of science education for social engineering national superiority in scientific discovery and applications in technology and engineering—enabled, of course, through mathematics (Weinstein, Blades, Gleason, 2016).

Zeidler (2014) offers a thorough critique of this deficit approach to school science education (deficit
The need for a clear, informed understanding of science was brilliantly made by humourist Joe Oliver of HBO’s Last Week Tonight (Scientific Studies, May 8, 2016); who, after giving example after example of ways scientific preliminary studies have been taken out of context by news media, reminds all of us that, “science is a very slow and rigorous process that does not led itself easily to sweeping conclusions.” This deep understanding of science, what we call the “Nature of Science” (NOS), is needed by all citizens if we are to make sense of the messages prevalent in the media, yet a STEM approach to science education, argues Zeidler, is too narrow to create such wide understanding of the NOS. In his paper, he calls for integrating a “holistic sociocultural model” (p. 13) into STEM, an approach that sounds very similar to the STSE approach.

You’re probably wondering if I’m advocating in this essay a return to an STSE approach to science education. While that would be my preference, I have to admit that in practice STEM is now the defining acronym in science education and likely here to stay, at least until the next acronym comes along. So, if we are concerned about the way STEM restricts science education to a particular market-driven focus serving a neo-liberal agenda, what possibilities exist within STEM to foster with all students a more holistic understanding of science that is moves in agenda from neo-liberal competition in innovation to international cooperation on the issues facing humankind?

In a play written with my colleagues Matthew Weinstein and Shannon Gleason we explain in more detail what we mean by “neo-liberal” as well as what possibilities exist for dealing with STEM (Blades, Weinstein, Gleason, 2014). We are not, of course, against innovation but ask questions about the purpose of innovation, especially in the light of the issues facing humankind and the other species invariably linked to our fate. We consider in play our situation vis-à-vis STEM and came to believe that as professors we should “try to re-define STEM, or even to work within existing frameworks, and operate in kind of complicity as infiltration in order to reshape and redirect the discourse” (Weinstein, Blades, Gleason, 2016). From our perspective, we believe it is possible for professors of science education and teachers to use STEM as a vehicle to undermine the very neo-liberal agenda that animates STEM by focusing STEM on the NOS.

Let me explain what I mean by this. First, the post-Sputnik reforms of science education are instructive because of their spectacular failure to encourage students to choose science-related careers (Blades, 1997). So, we should not expect STEM will automatically work to produce the scientists, engineers, and technicians assumed to be the natural product of such a focus. But an additional, important lesson of the revisions of the 1960s and 1970s is that curriculum is less of a product to be replicated in the classroom and more of a process, a lived and living event (Aoki, 1993) in the classroom formed in the dynamic interaction of teachers and students. So, while “STEM” may be hegemonic, the meaning of STEM remains open to negotiation with teachers and students, at least in jurisdictions where there is less surveillance and control through externally-imposed examinations. This is the great lesson of the post-Sputnik reforms: Teachers’ views and approaches to teaching matter in curriculum change. Any attempt to circumvent teachers in the change process will invariably find that teachers modify, adapt, sometimes completely deviate from what the curriculum designers expected. So, my colleague, as someone likely teaching the next generation of science teachers, it is important to remind your pre-service teachers that they, together with their students, are the curriculum—what occurs in their classroom will be science education.

Seizing this opportunity presents a way to use STEM to broaden science education beyond a neo-liberal agenda of market economics. In my career move to the positive, or what I consider to be positive, I have begun to investigate the idea of beauty, from the philosophical perspective of aesthetics. I believe that aesthetics may offer some help in expanding the NOS in STEM by using the ideas contained in the acronym itself.

Consider, for example, the school unit “structures and design”—a focus (often around Grade 5) on
building structures. This sort of topic is pure STEM—a unit on engineering that looks at the application of force to the design of a structure, such as a building or, typically, a tall tower. Students can examine various materials, such as plastic (often straws), wood, metal, etc. and measure the height of various towers, thus incorporating all the elements of STEM. But, teachers are able to take one more additional step in this unit by adding considerations of aesthetics: Is it possible to make a tower that is not only function (e.g., can hold aloft a weight) but is also beautiful? Why would such considerations be important?

To encourage this expansion of STEM, we might introduce students in Grade 5 to the controversy around the building of the Eiffel Tower in Paris. As Rutherford notes in his historical novel, *Paris* (2013), the design for the Eiffel Tower by Gustave Eiffel were submitted as part of competition for designs for the 1889 Universal Exhibition (*World’s Fair*) held in Paris to mark the centenary of the French Revolution. While Eiffel was already famous for designing and building the Statue of Liberty, there was considerable controversy around his winning design for a tower. When the work began a protest by the artists of Paris was published in the Parisian newspaper *Les Temps* on the 14th of February, 1887; the collective of artists, writers, sculptors and others argued that the tower would be “ugly” and in poor taste, a “truly tragic street lamp” or phallic-like construction that would spoil forever the Paris skyline (Toureiffel, 2015). Eiffel responded to the concerns of Parisians in an interview that appeared in the same issue of *Les Temps*: “For my part, I believe that the Tower will possess its own beauty. Are we to believe that because one is an engineer one is not preoccupied by beauty in one’s constructions, or that one does not seek to create elegance as well as solidity and durability?” (Toureiffel, p. 1). History, of course, has come to vindicate Eiffel’s view of his famous Tower, which is now one of the most important landmarks and tourist attractions of Paris (Gallant, 2002).

But is the tower beautiful? When we examine in more detail the actual construction of this Tower and the physics knowledge needed to construct what is, essentially, 4 arched pillars curving in to meet and support each other as a single tower that reach a height of 275 meters, we can gain an insight into the challenges of building a structure with curved supports. Many physicists, studying the forces that affect the design of the Eiffel Tower conclude that in design and science the Tower is beautiful, an amazing achievement of human engineering that is beautiful precisely in its simplicity and a symmetry designed to achieve maximum torque to counter wind resistance (Gallant, 2002). As Billington (1984) notes, a structure is beautiful if it maximizes three conditions: minimum use of materials, minimum cost, and maximum aesthetic expression: The Eiffel Tower achieved all of these and, in fact, although the Tower was destined to be dismantled after its 20-year lease expired, Parisians fell in love with the Tower and demanded that it become a permanent structure; it stands to this day, 117 years after construction.

By raising the question of beauty we invite students into a wider conversation about the purpose of their science education; does it matter if a structure is beautiful? What does beautiful mean? Suddenly the challenge in Grade 5 is not only to build a tower, but one that is beautiful and to accomplish this challenge, one would need to know the physics of tower design, possibilities of materials and technologies available to assist in the design, but also appreciate social norms, changes in design preference over time and the consequences of building something that does not last—in other words, a more demanding, robust science education than the narrow market focus of STEM.

A sustained conversation about beauty in STEM science reorients science education from a focus on acquiring skills for employment to a wider appreciation of the nature of science itself. At the heart of this discussion is the philosophical question as to why we find some aspects of nature and some aspects of technologies (such as towers) beautiful. Some philosophers, such as Kant, considered beauty an expression of culture: Beauty is in the eye of the beholder. But many philosophers, such as Aristotle, argue that nature is *inherently* beautiful or, as Hegel argued, the sense of what is beautiful is phenomenologically transcendent (see Blades, 2015). The writings of many scientists seem to support this perspective; for example, the great botanist Joseph Paxton described his field as “the science of beauty” (Paxton, 1838, ix) and John Tyndall, in
his study of glaciers, 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). As Girod et al. (2003) observe in their paper arguing for including aesthetics in science education, “a surprisingly large literature exists on the role of aesthetics, creativity, passion, beauty and art play in the lives and learning of scientists” (p. 575). They argue that understanding aesthetics is a way of teaching students that learning in science is a “synthetic process in which cognition, emotions, and actions emerge” (p. 576). In other words, when we bring beauty into science education we reveal to students that science is a complex human endeavour where emotions and a sense of awe and beauty have a natural place. In her last published work, the famous environmentalist Rachel Carson argued that as children the world is “fresh and beautiful, full of wonder and excitement” but adds that, “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). Including concepts of beauty in STEM could also be restorative to a deeper, more authentic relationship with nature and the technologies we create.

My recent research examines the effects of introducing aesthetics in pre-service science education methodology courses via an assignment. While this is preliminary work, the results to date suggest that, “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” (Blades, 2015; emphasis in text). In other words, pre-service teachers intending to teach children and young adults science developed a clearer and deeper understanding of the nature of science by exploring an aesthetic appreciation of an aspect of nature, a technology or (in one case) a particular mathematical expression. The most common experience of the pre-service teachers through this assignment was an understanding of the importance of curiosity and determination in science and a recovery of a childhood sense of beauty and wonder. In some cases, this recovery also promoted a strong sense of responsibility for caring for the aspect of nature they studied (for more details, see Blades 2015).

Developing aesthetic appreciation is part of what Dewey called a “scientific habit of mind” (Dewey, quoted in Rudolph, 2014, p. 1061). In his review of Dewey’s concept of science as method, Rudolph reminds us that Dewey believed that democracy requires a citizenry that can engage in “sound empirical reasoning with respect to everyday affairs” (p. 1061). Cavanaugh (2013) argues that from Dewey’s perspective, empirical reasoning necessarily includes the aesthetic experience of the sublime where “as a result of these experiences, the learner begins to see and be in the world differently—sublime and educative experiences transform the way we see the world” (p. 64). Dewey always maintained the major goal of education was to develop a citizenry willing and able to engage in the sometimes-difficult conversations necessary in democracy and, to Dewey, this requires a full science education experience that includes aesthetics.

In this way, including aesthetics in STEM counters the hegemony of individualism and market-based capitalism that animates the discourse of STEM. But aesthetics can also work to undermine neo-liberalism by raising questions with students about what is not beautiful—the question of the “ugly.” There is surprisingly little discussion on the sense of “ugly” in philosophy and my examination of this concept, the not-beautiful, is very preliminary. Parret (2011) notes that those who do take up the question of the ugly argue that ugliness is a degree of beauty; i.e., less beautiful. Parret argues that the ugly is “not a descriptive but evaluative category” that has a “necessary affective meaning” (p. 5). From this perspective, we might incorporate in STEM the more exact questions about what students find to be not-beautiful and why that is. I recommend this line of research to you as a new and potentially very fruitful area to explore.

Personally, I find some technologies both beautiful in design and creativity and yet “ugly” at the same time. For example, the symmetry of a line of pipes intended to carry water or oil can be seen as beautiful in design, but the ruination of the land when a pipeline bursts can be considered ugly; certainly
pictures of birds covered in crude oil to me speak of a form of ugliness, a destruction of the natural by a human invention in places not intended. Infusing questions about the nature and role of existing and emergent technologies provides a counter discourse to a superficial view of technology as a means of employment. For example, teachers might ask with students the following questions concerning technologies: Who is served by this technology? Does this technology promote social and economic justice? Does this technology respect cultural diversity? Will this technology, if emergent, allow a reasonable time alone and time with others? Does the technology humanize living? (Questions adapted from Elwood (1997), Blades (2001), Postman, (1993), and Mander (1991)). When we ask questions such as these, STEM becomes less of an imposition and more of an opportunity to move beyond the intentions of STEM itself as long as we see curriculum change as primarily an act of interpretation by teachers and students. I believe the grouping of science, technology, engineering and mathematics is not necessarily a delimitation of what we can do in science education; the influence of STEM as an acronym entirely depends on all of us involved in educating the next generation of citizens realizing that the meaning of STEM lies entirely in our hands and in the hands of those new science teachers.

I look forward to continuing a conversation with you about some of these themes and ideas and I sincerely wish you every success in your new career,

David

References


