STEM *and* LEAF

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Abstract

In response to society's expanding uses of technology, it is clear that the goals and contexts of schooling have, and are continuing to undergo a major redefinition. The continued and pervasive increase in the use of science and technology within our broader society has increased the perceived need to implement an increasingly technological perspective in schools and in curricula. This general trend towards incorporating more technology is evidenced by current STEM Initiatives seen worldwide. In this paper, using techniques such as narrative, analogy and metaphor, I will offer the beginnings of a socio-cultural and environmental critique to the current STEM movement. I will begin by examining 'the roots' of STEM and then follow this storyline with some of the more recent critiques and reforms aimed at broadening STEM perspectives (eg. STEAM and STREAM). I will then assert that students exposed to the STEM model of science education are being asked to understand environmental and technological issues only within prescribed or predetermined (political) limits. I argue that without the inclusion of an important socio-cultural critique, education of this nature works only to maintain and promote hegemonic beliefs and values while failing to address the collateral problems relating to our scientific and/or technological epistemologies. This paper goes on to describe an expanded and alternative framework that might define a more complex undertaking for education: one that involves a consideration of scientific, economic, ethical and aesthetic perspectives alongside each other. This modified ecological framework which I describe as 'STEM *and* LEAF' is then described with the intent of furthering an enhanced discussion and critique on the efficacy and suitability of the current STEM movement worldwide.

Figure 1: The metaphor of STEM

Introduction

Scientific literacy has long been a component of science education reform agendas and while no single definition of scientific literacy prevails, it is often defined in the context of the current national concern and usually focuses on science and scientific knowledge in terms of concepts, models, theories, and principles that all students ought to know and understand and use (Roth & Barton, 2004). This definition does little to address diverse audiences' (especially women and minorities). They argue that this is due to science classes becoming, mechanisms for controlling what it means to know and do science rather than a source of empowerment where students are valued for their abilities to contribute to, critique, and partake in a just society (Roth & Barton, 2004).

The use of the 'STEM' acronym to describe the current round of curricular reforms arose in common usage shortly after an interagency meeting on science education held in the US in 1998 by that country's National Science Foundation (NSF). At that meeting, after first expressing some discomfort for the older acronym (METS), the NSF then instituted the change to the current acronym. Since then, the STEM designation has been applied broadly to a variety of projects and programs worldwide. These are most frequently aimed at integrating outcomes and skills related to its constituent elements or disciplines, namely: Science, Technology, Engineering and Mathematics.

Since STEM was first conceived in the late 1990s, there has been increasing momentum, funds and energy aimed at implementing an 'integrated' STEM education into schools. Integrated models of STEM education usually refer to at least two or more of the discipline areas being applied together to solve problems or to design/create products. Despite all of the publicity around STEM reforms, as well as a plethora of public and private funding available for its programs, I feel it is now prudent to ask if STEM education (alone) is capable of achieving the outcomes that are expected of it. If not, what are the inherent overarching goals of the STEM movement and what other efforts will be needed to ensure its success? This paper will hope to address these questions and the implications for K-12 classrooms and beyond.

Background

Is there an *E* in STEM?

Nowadays, STEM innovations are considered by governments to be key to our global economic future and increasing funds, time and energy are being put into improving STEM education (European Union, 2015; Hackling, Murcia, West, & Anderson, 2014). Still, since the inception of STEM and billions of dollars in expenditure, these initiatives have not created the desired increase in students selecting STEM subjects in school or an expected increase in STEM graduates from postsecondary institutions (Burke & Baker McNeill, 2011).

Blackly and Sheffield (2016) stated that this problem may lie in the *E* of *STEM* noting that the constituent *E*: for *Engineering* is not yet a subject in public schools. Despite this point, I might suggest that the *E* in STEM might equally represent an *E for Economy,* as the hoped for growth in STEM innovations is increasingly seen as a way forward to securing a strong economy with highly capable workers for the future (Chubb, 2015). Blackly and Sheffield (2016) argued for another type of *E* – possibly that of *Ethics* or even *Environment* as more appropriate vision for science education reform.

On a closely related theme, Orr in his book, *Earth in Mind* (1994) discussed what he termed the ‘problem of disciplines’ and the ‘discipline of problems’ in an essay about the root of society’s ‘unsustainability’ problem. Orr saw the problem as set in a lack of interdisciplinary approaches in delivery for *all* curriculum. I concur with his central argument: that ‘real world problem solving’ would form a truer context for the reform minded reorganization of curriculum. I also assert that the STEM movement does create a *potential* context for this type of learning and this can be argued is its greatest (unrealized) promise.

From the theoretical perspective of the educational reform movement, and for new models of teaching and learning, it is indeed feasible that scientific, technological or environmental topics could form a more authentic context for learning, thereby making science content more meaningful to students. In turn, this might facilitate deeper understanding of subject matter: a key goal of current reform efforts in science education. Still, within a largely economically motivated STEM model – ‘environmental’ topics are most often reduced to the simple transmission of knowledge related to nature study.

Importantly, the guiding principles for environmental education have been discussed as far back as the Tbilisi Declaration (1977) and these have focused on a type of interdisciplinary learning that is the result of a reorientation of disciplines that could facilitate an integrated perception of the ‘problems of the environment.’ Ideally, students working in an integrated and reformed curriculum could find opportunities to work independently and collaboratively towards a resolution of local, and global environmental problems (Orr, 1994).

However, despite more than 40 years of rhetoric about the integration of environmental sustainability in science education, the largely *economically* driven Western education system still tends to reinforce competition and consumption rather than care and conservation (Sterling, 2001). Despite its potential, I assert that the current model of STEM has not taken up the problem of either E (*ethics* or the *environment*) in its current form. The reasons for this are complex and systematic – and so referring back to a STEM metaphor -- a cursory look at the ‘roots’ of STEM and the trajectory that current science education reforms have taken over a longer timeframe is required.

The roots of STEM

In reference to what I would refer to as the ‘roots’ of current STEM initiatives worldwide, it is important to also understand that prior to STEM a number of other widespread and intensive reform efforts were undertaken also with the ultimate goal of making science curriculum more relevant and accessible. These became known as the STS and STSE movements and effectively set the educational context for the integrative efforts for science education that followed.

The STS movement

The Science, Technology and Society (or STS) perspective in science education arose out of the more general trend towards incorporating more technology in science curricula and a parallel need to include technology-focused components in all school curriculums (Layton, 1993). These reforms were mirrored by a drive to also increase the number of computers and other technologies in schools. Such moves were also evidenced in the development of technology education in Australia, Canada, the UK, the USA and many other western countries. In response to this pressure, many jurisdictions also included technological education components across the curriculum, in keeping with the trend to make education vocationally relevant and *less* about developing human, or social potential (Zandvliet, 2003).

In consideration of the initial development of the STS perspective, there were several versions of the case for incorporating technology in the curriculum of a general education by combining it with science. This wider role for science education was then associated with a science curriculum that would be more context-based, and that would give more prominence to the applications and implications of science (Layton, 1993). In reviewing a variety of science-technology-society (STS) courses, Layton distinguished between: (1) science-determined courses in which knowledge was similar to traditional science education, with STS material added on; (2) technology determined courses in which the science content was determined by its relation to the technology studied; and (3) society-determined courses in which the science / technology studied were determined by their relevance to the societal problem under consideration.

In the earliest days of the STS movement, many scholars argued that the essential elements of curriculum reform lay in the first option: the inclusion of technology education within science. Kings (1990) outlined the factors he believed were encouraging educational systems at that time to implement this technology-focused curriculum. First, he espoused a greater recognition of the social context of science and technology in the light of contemporary issues as automation and genetic engineering. This viewpoint also espoused a type of technology education that would focus on problem solving and the need to draw on knowledge and skills from a range of disciplines. Still, I assert that most often the problem-based approaches (at that time) were techno-centric in their view of social problems and that resultantly, science and technology were most often looked at as potential solutions and seldom critically examined for their own underlying values and dominant (hegemonic) practices (Sammel & Zandvliet, 2002).

At the outset of the STS movement, many outlined a need for science and technological expertise in both developed and developing countries. For example, Kings (1990) saw persistent factors as low achievement levels, pressures from employer groups, and increasing government expectations as working together at that time to stimulate a change towards a more technically focused curriculum and he described how these had been implemented throughout the world, especially in Australia, Canada, the U.S. and the U.K. The resulting STS focused science curricula and their greater implementation of technology was taken by many to reflect the needs of teachers and students while also meeting society's expectations for change. I assert that the adoption of techno-centric views of curriculum then (and now) make assumptions about the nature of social or environmental problems and assume that these may be solved through purely technical means. Worldviews such as these had in the past been countered by the environmental education (EE) and education for sustainable development (ESD) movements. This critique would eventually lead to an attempted expansion of this narrower framework in order to include environmental issues and presumably by extension: environmental education (EE) and/or Education for Sustainable Development (ESD). However, this view of environmental issues remained informed by the same technological focus of the previous STS perspective and became known (by its extension) as STSE.

The STSE framework

The early years of this century saw a new secondary science curricula introduced in several jurisdictions (including Canada). The major distinction between these and previous reform efforts was the inclusion of how science broadly relates to technology, society *and the environment* (STSE). Though each curriculum differered in its approach, In Canada, each was reflective of the Pan Canadian Science Framework published a few years earlier by the Council of Ministers of Education in Canada (1997). The goal of that reform was to generate scientific literacy by encouraging citizens to understand the impact science and technology has on their lives. Similarly, the goal for the STSE perspective at that time was to link scientific concepts and skills to real-world problems (eg. Ministry of Education, 2000). As such, many critics asserted the framework largely replicated epistemological assumptions inherent in the STS framework that preceded it.

The argument could be summarised as this: if the STSE aspect of curriculum was meant to encourage the discipline of science education to address both social and environmental issues arising alongside scientific / technological advancement - it would be difficult to do so from *within* a dominant, scientific worldview. STSE as constructed in this framework was seen by many as effectively marginalizing the traditional environmental education discourse: a phenomenon that I then described as an STS*e* framework (Sammel & Zandvliet, 2002). For example, in the Ontario curriculum, the STSE lens offered a socio-historical perspective of scientific concepts but also tended to focus on a 'history of science' so as to gain a greater understanding of only 'positive' scientific connections rather than critiquing the way science has been socially constructed. In so doing, the 'invisible social, cultural and political conditions' that might also work to create and maintain scientific understandings were not recognized

Importantly, the STSE element of curriculum also continued to stress mainly facts and information and due to its inclusion of (only) political appropriate issues, it was seen by critics as producing only partial understandings of other important ethical or environmental considerations. In particular, using the lens of critical pedagogy -- many scholars saw STSE as a potential agent in maintaining hegemonic ideals and power relationships (Sammel & Zandvliet, 2002). In contrast, the inclusion of a socially and environmentally critical/STSE perspective would have instead had the potential to challenge dominant social paradigms while still providing for socially relevant scientific understanding. However, this was not the goal of STSE as it was then framed. In contrast, critical educational discourses were (and are) quite common within the environmental education and education for sustainable development perspectives.

Environment as EE or ESD?

Central to my brief history of science education reform here is also a different and parallel debate that was occurring in the environmental education literature. Ever since the inception of the UN Decade of Education for Sustainable Development (2004), there had been considerable disagreement as to whether the UN designated reforms known as Education for Sustainable Development (ESD) were essentially an extension of Environmental Education (EE) or a specified strand within the field (see Fien, 1995; McKeown & Hopkins, 2003). While some saw ESD as a successor to EE, others argued that ESD has not added anything to the traditional discourse found in EE (Sauvé 1996). Still others questioned the conceptual and ethical (economic) foundations for ESD (Stevenson, 2007; Jickling & Wals, 2008). These types of critiques were similar to those that were being leveled at the STS and STSE perspectives that were winding their way into earlier science education reforms at that time.

Between the competing conceptions of EE and ESD, other scholars discussed ESD as a legitimatization of behaviorist and constructivist positions (McKeown & Hopkins, 2003; Sterling, 2010), while others saw a distinction between the concepts in each perspective as informed by *environmental ethics*. Here EE was seen as the more eco-centric concept, whereas the ESD perspective was seen as representing a more anthropogenic worldview. While this debate remains largely unresolved, the later UNESCO proposal for the Global Action Programme (2013) side-stepped the issue by applying the term 'education for sustainable development' for all activities that promote such evolution of curriculum, regardless of whether they use the term ESD (depending on their history or context) or environmental, sustainability, global education, or development education.

This debate within the environmental movement is also important for this consideration of science education reform as it brings forth the importance of ‘ethical considerations’ as part of global curriculum reform efforts. Importantly, this aspect of moral and ethical reasoning was (and is) still important for science education reform. Within Science education circles, this perspective eventually became known as the Socio-Scientific Issues (or SSI) perspective.

Socio-scientific Issues (SSI)

The advocates for the Socio-scientific Issues perspective (SSI) argued that in the context of science education, the definition of scientific literacy should go beyond a simple understanding of scientific concepts to also address social functions of science that recognize all voices that make up our societies (Abd-El-Khalick, 2003; Zeidler & Keefer, 2003; Sadler, 2002). Such a definition included a critical approach to science and how it related to society. In essence, SSI education in this model could be seen as science education for *citizenship*. Abd-El-Khalick (2003) claimed that scientific literacy needs to address the ability to make informed decision regarding science-related personal and societal issues (Abd-El-Khalick, 2003).

Sammel and Zandvliet (2003*)* called for a definition that emphasizes the importance of the ability to connect science to its social, historical, cultural, linguistic, political, and moral context (Sammel & Zandvliet, 2003). Zeidler and Keefer (2003) defined scientific literacy as entailing, ‘practice and experience in developing habits of mind such as acquiring scepticism, maintaining open-mindedness, evoking critical thinking, recognizing multiple forms of inquiry, accepting ambiguity, and searching for data-driven knowledge (Zeidler & Keefer, 2003). Sadler (2002) extended this definition of scientific literacy, arguing that scientific literacy should also include moral dimensions, since these are considered a part of decision making with regards to SSI (Sadler, 2002).

It could be said that much of the discourse around SSI was effectively a critique of the STS and STSE movements. For example, Kolsto (2000) argued for science education to go beyond a simple society and technology connection towards a curriculum that empowers students as citizens, that emphasizes science as an institution, and critically looks at how scientific knowledge is produced.

Zeidler, Sadler, Simmons and Howes (2005) also examined flaws of STSE and where it fell short in achieving its goals in; making science more meaningful to students, using curricula to engage students, and in integrating science content into social and technological contexts. They articulated that the goals had not been met because STSE issues were then seen as removed from personal experience.

Kolsto (2005) identified several varied criteria, including the scientific content, social aspects, theoretical adequacy, and manipulative strategies as all important for science education. He concluded that a critical examination of scientific texts is essential for science, in order to adequately prepare students and citizens to deal with socio-scientific issues. Unfortunately, little of this perspective has found its way into the current discourse around STEM with much of its epistemology remaining consistent with the earlier reform efforts aimed at technological and economic ‘progress.’

The critique

As I have noted, the term *STEM* today is mostly used when addressing education policy and curriculum choices in schools, to improve competitiveness in science and technology with implications for workforce and economic development. In this, I echo the earlier critiques of science education reform initiatives as they uncritically promoted economic rationalism with the goals of increased national competitive advantage and the growth and legitimacy of science and technology and engineering based industries while important concerns for social and environmental justice take a distant second place to the demands of international competition

The influence of governments then, grounded in Western capitalism, economic globalization and rationalism, continue to change how science is written, perceived, understood and taken up by the education system (Lyotard, 1984). While STEM perspectives might aim to reduce the foreignness of science so that students can gain greater understandings of contemporary problems: it is assumed that simple (hegemonic) awareness alone will guide their practical judgement. What fails to be recognized within the STEM paradigm is that prevailing social, cultural or political conditions that create and seek to maintain language, meaning, subjectivities and injustices are not included in the discourse (Weedon, 1997).

From a critical or poststructuralist perspective, science and technological knowledge (like all knowledge) is not objective, universal and fixed, but is located within discourses that constitute subjectivity and meaning (Peters, 1998). As a result, knowledge production should be seen as part of a larger network of power relations. In this way, the STEM perspective on science education and its restricted knowledge base, could be described as knowledge constituted within a discourse heavily invested in an ideology that Peters (1996) called *Homo economicus*: a form of economic rationalism. The STEM perspective then, has a role to play in what knowledge is produced, packaged and sold to advance the goals of increased national competitive advantage and economic production and consumption.

Further, STEM ignores important dimensions of social and environmental issues that involve emotional concerns, beliefs, aspirations, aesthetics and vested interests. To this end, what this curriculum leaves out then highlights that education can never be neutral -- as dominant educational agendas seek to maintain and reproduce a particular social structure. Within the current mandate, STEM initiatives can be viewed a type of scientific literacy that takes place only within safe and politically acceptable limits. Its curriculum mandates hegemonic beliefs and values, ignores the ways in which science, by way of the government, has been put in service of economic development and does not address root causes of social and environmental injustices.

Without the inclusion of an important socio-cultural critique, education of this kind maintains and promotes hegemonic beliefs and values while not addressing collateral problems relating to scientific or technological developments: many of which are linked to environmental and social injustice. Still, this critique is not about condemning all of the STEM initiatives but rather, exploring how these situate science within political agendas. Indeed, scientific facts and information are needed, but if they are only presented in neutralized forms, are disconnected from other social constructions, then we are not communicating to students the strengths and limitations of Western traditions of science or indeed, what it means to be scientifically literate.

What's core to STEM?

Recently, other disciplines have chimed in to the chorus of the current STEM initiatives, arguing to be included in the mix of disciplines that might eventually form the 'core' of these new and expanding curriculum efforts. While this is understandable from the perspective of accessing limited government resources for curriculum development (and for research), the variety of these approaches require a little more explanation. Two key examples of this type of initiative have been described as STEAM and STREAM.

STEAM can be described as an approach to learning that espouses the disciplines of Science, Technology, Engineering, *the Arts* and Mathematics as access points for student inquiry, dialogue, and critical thinking. *STEAM* projects are science-based, but incorporate artistic expression. Advocates for this approach argue that this may produce students who take risks, engage in experiential learning and persist in problem-solving. Another type of initiative, *STREAM*: adds another layer to STEM and STEAM: reading and writing. Advocates of STREAM education see literacy as an essential part of a well-rounded curriculum, as it requires critical thinking and creativity. STREAM projects are similar to STEM or STEAM, but include the requisite reading and writing components.

Many are not convinced that adding an A or R to STEM is beneficial. In fact, some critics see it as a dilution of STEM's focus and objectives. Advocates for STEM caution against expansion to STEAM or STREAM arguing that while it is beneficial for students to have exposure to the arts and to know how to communicate, those pushing STEAM and STREAM are external to the STEM community. Their goal is not to promote science education, but instead to increase focus on the arts and reading. One of my colleagues once included a humorous extension to this line of thinking – that instead of adding reading and writing to STEAM, we add the *entire* curriculum, which we would then designate with a *C*. The resulting movement could henceforth become known as *SCREAM*.

STEM + Art and Design	= STEAM
STEAM + Reading/Writing	= STREAM
STREAM + all Curriculum	= SCREAM?

Figure 2: Approaches to STEM

In some ways, I agree with both sides of the argument for an expanded view of STEM initiatives and this has led to somewhat of an epistemological confusion on what to propose as a constructive remedy to my critique. On the one side, I concur that more is needed for an informed and scientifically literate citizenry: particularly with regards to social, ethical and environmental considerations. Still, I am not convinced that attempting to imbed these within the current STEM discourse is rational or epistemologically sound. Instead, what is needed is something more … something that we could take up alongside the current ideas about STEM and that would add value. Playfully then, I might suggest that this alternative epistemology (one instead focused on learning) might take the form of a *LEAF*.

Consider a LEAF?

When environmental concepts are taught across the curriculum and not within mandated (subject-specific) curriculum, they run a risk of being marginalised. So how is this dichotomy to be reconciled, a hegemonic and routine 'science education' juxtaposed against a more holistic, yet ever marginalised environmental education? My examination of past reform initiatives (the roots of STEM) yielded some insight for the assertion that learning about environmental issues has not in the past (and may not) form a core part of the curriculum of science: especially within the current drive to implement STEM.

Recently described attempts to broaden STEM to include creativity and communication (the so called STEAM and STREAM initiatives) are a case in point. They have to some extent been marginalised as they are not seen as contributing to a dominant economic and technological discourse. As a response, I propose a second agenda to be taken up alongside the current curricular and disciplinary focus of STEM. In my opinion, this focus on curriculum must be balanced with a focus on student *learning*. In this -- and speaking as an environmental educator -- I would assert that learning through direct experiences (in the community and the environment) forms a further focus to our current preoccupation with STEM curriculum. This line of thinking lead me to re-engage the metaphor in proposing the acronym of *LEAF: Learning* about the *Environment* through *Aesthetic Function.* This might form a second (complementary) piece to the STEM agenda.

Indeed, outside science education, much attention has been paid to such other forms of intellectual capacity and learning such as aesthetic, social and emotional capacities for learning. Goleman (cited in Cohen, 1999) in *Emotional Intelligence*, provided much evidence for social and emotional intelligence as the complex and multifaceted ability to be effective in all the critical domains of life. Goleman states the point simply: it's a different way of being smart. These multiple intelligences are socially based and interrelated: it's difficult to think of linguistics, musical, and interpersonal intelligence out of the context of social and cooperative activity. I would add to this list the discipline of science and the current STEM initiatives.

While, the *LEAF* acronym could be seen as a playful way to make this point, there is a rational aspect to its inclusion as a complementary focus for learning in science as well. First, from an experiential learning perspective, multiple viewpoints from the wider community (not just science) form a truer context for learning about scientific, social or environmental issues. Further, learning about local communities and environments also provide opportunities for students to develop social and emotional competencies: which could be described as the ability to understand, direct, and express the social and emotional aspects of one's life.

Examples of these expanded learning competencies include self-awareness, control of impulsivity, working cooperatively, and caring about oneself and others. Knowledge of ourselves and others as well as the capacity to use this knowledge to solve problems creatively also provides an essential foundation for both learning and the capacity to become an active citizen (Cohen, 1999).

Further, the inclusion of an *aesthetic* functioning is also an important part of the learning process. Contemporary developments in the cognitive sciences now acknowledge this and can highlight how students learn in a variety of different ways (Bransford et al., 2003). The inclusion of aesthetics and its inherently different neural pathways for learning effectively (and affectively) allow students an additional 'way in' to learning about their world and its diversity of environments and possibilities. Effectively, one could also consider this as a key alternative pathway to learning about *science* and the *environment* through complimentary strategies

STEM *and* LEAF

Figure 3: Stem and leaf (a Metaphor)

For myself, STEM *and* LEAF represents another set of ideas that might positively inform the pedagogy of STEM in future. Essentially a form of *ecological education*: this notion connotes an emphasis on the inescapable ‘embeddedness’ of human beings and their technologies in natural systems. Instead of considering nature as ‘other’ (a set of phenomena capable of being manipulated like parts of a machine), ecological education views the human enterprise as just one part of the natural world and that human societies and cultures are essentially an outgrowth of interactions between our species and particular places (Smith & Williams, 1999). Such an approach allows educators to consider multiple perspectives on an issue or problem. The dominant principles that inform the work of STEM educators subscribing to this type of framework include:

1. development of affinity with the environment through direct experiences in nature;
2. grounding learning in a sense of place by exploring surrounding communities;
3. acquisition of practical skills needed to regenerate human and natural environments;
4. introduction to occupational options that contribute to local cultures or communities;
5. a critique of cultural assumptions upon which modern industrial society has been built.

The above noted framework is merely a starting point for further discussion regarding the epistemological underpinnings which guide the development and implementation of all science curricula. While the ideas framed here contrast with some of the STEM education perspectives now espoused by Western governments, they also offer some further ideas about how science may be conceived, interpreted or described. Further, this proposed framework should itself be rigorously critiqued and examined for its underlying assumptions and beliefs so as to stay true to the goal of re-examining the complexities of both scientific and environmental literacies.

Summary

In closing, teaching about science *and* environment through a combination of strategies that I describe here as 'STEM *and* LEAF' may be an interesting proposal to consider moving forward. Such an idea acknowledges that science and environmental learning is a complex undertaking involving a consideration of scientific, economic, ethical and political perspectives that at once reference different though possibly complementary epistemologies. It further describes how educating students about science and the environment could at once provide students with opportunities to learn about the functioning of natural systems, to identify their beliefs and values, while also considering a range of views to (ultimately) make more informed and responsible choices as citizens.

In addition, direct experience with community and environment are central to this platform as they provide students with a deeper understanding of natural systems and human impacts on those systems (Ministry of Education, 2007). Responsible action is also considered integral to, and a consequence of this type of learning. For STEM and LEAF to work, our education system needs to address the study of complex systems in two ways: first, it must examine the complexity and inter-relatedness of natural systems and second; it must looks also at human-created systems, both those that are built and or part of the social fabric.

In this model, students also can learn how human decisions and actions have environmental consequences *AND* that environmental awareness can enable students to develop an aesthetic appreciation for the environment. Finally, the study of a science education through STEM, and an appreciation of the environment through LEAF may enable students to develop an environmental and social ethic. In particular, frameworks such as this may provide a more inclusive model generally for the teaching and learning of science (and STEM) worldwide.

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