An Ecological Framework for Science Education

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Abstract: This paper provides a review and critique on the curricular implementations of a variety of issues-based approaches to education including the use of Science Technology and Society (STS) and Science Technology Society and Environment (STSE) perspectives that are influencing curriculum efforts in the US, Canada and worldwide. By characterising aspects of these implementations as a form of *technocentric* curriculum reform, the paper goes on to describe the problematic nature of this development for science and environmental education. The paper then provides a description of an ecological (context driven) framework for science education, which references the emerging discourse around socio-scientific issues, place-based education and is further grounded in an ecological conceptions of science education that emphasize the 'embeddedness' of human societies and cultures (and their technologies) within place-bound communities. The model describes a range of ecological, socio-cultural and technical influences that provide a framework for educators' diverse interpretations of curriculum.

Keywords: Science education, environmental education, science-technology-society, socio-scientific issues, ecological education.

TECHNOLOGICAL CHANGE AND SOCIETY

The world continues to advance technologically and societies around the globe are continually asked to cope with a barrage of scientific and technological developments. Still, despite this 'progress metaphor,' environmental and social problems seem to present themselves at ever alarming frequencies. Goumain [1] stated that due to the accelerated pace of technological change, organizations are forced to cope reactively, adapting to changing environmental conditions only when these have become intolerable. I believe this is also true of the educational enterprise, which has to manage the continued introduction of technological perspectives while at the same time being subjected to a variety of other external factors that have greatly influenced their inception.

Gardiner [2] described a framework for thinking about these pressures, which drive change in our increasingly technological lives. The model consists of three spheres of influence, which he described as ecosphere, sociosphere and technosphere. The *ecosphere* relates simply to a people (or group's) physical environment and surroundings, whereas *sociosphere* relates to an individual's net interactions with other people within that environment. Lastly, *technosphere* is described as the total of all person-made things (present and future) in the world.

Realistic interpretations of change incorporate a balance between the contributions from each of the spheres of influence. However, as Gardiner [2] noted, for many organizations, the influence of the *technosphere* often drives the dominant changes in a system. In relating curriculum reform to this model, the technosphere relates effectively to "teaching about the tools." A central assertion for this paper would be that this influence manifests itself in formal school curricula through the adoption of a technocentric curriculum. This occurs at the expense of other mediating influences, which include the effects from local geographies (ecosphere) as well as those from local cultural and social norms (sociosphere). This paper argues that the current implementations of Science Technology and Society (STS) curricula (however envisioned) are salient examples of an increasingly *technocentric* view of curriculum.

DEVELOPMENT OF STS AND STSE FRAMEWORKS

Layton [3] noted that an increase in the use of science and technology within society had increased the need to implement an increasingly technological perspective in schools and in curricula. He noted that the general trend towards incorporating more technology is evidenced by the need to include technology-focused components such as the STS perspective in school curricula. Such shifts are also seen in the development of a distinct technology curriculum in Australia, Canada, the UK and in many developing countries in the ensuing decades (eg. National Research Council [4]; Council of Ministers of Education [5]. In response to this pressure, many jurisdictions included technical education components across the curriculum in keeping with a general trend to make education more vocationally relevant.

Worldwide calls for scientific and technological literacy have been historically based on the premise that technological societies need sufficient numbers of qualified professionals who can participate fully in the modern scientific-technological endeavor and who can thus propagate or maintain the economic system. Therefore, scientific literacy also became a technological goal for a

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"science education for all citizens" [6]. Evolutions in science and technology, coupled with community based environmental concerns and reforms in science education during the last three decades for example, have contributed to the creation of the science-technology-society (STS) theme within science education reform in the U.S. [7].

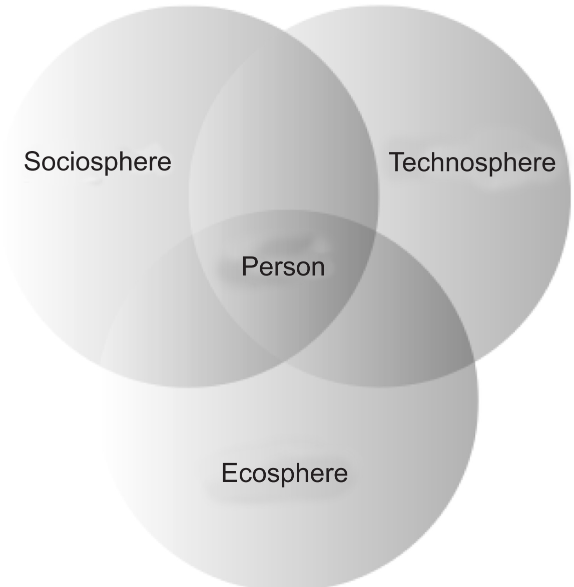

Fig. (1). Framework of change factors (from Gardiner).

In consideration of the historical development of STS frameworks, there were several different arguments for incorporating technology into the curriculum of a general education by combining it with science [3]. In reviewing the variety of such science-technology-society (STS) courses, Layton distinguished between: (1) science-determined courses in which the sequence of knowledge is identical to that of traditional disciplinary science education, with the STS material added on; (2) technology-determined courses in which the science content is determined by its relation to the technology or the socio-technological issue being studied; and (3) society-determined courses in which the science and technology to be studied are determined by their relevance to the societal problem under consideration.

In the earliest days of STS frameworks, many scholars saw what they believed were the essential elements of successful curriculum change in the implementation of the first option: the inclusion of technology education within science courses. Kings [8] was one of the first to outline the important factors that he believed were then encouraging educational systems to implement technology curricula. First, he noted a greater recognition of the social context of science and technology in light of such contemporary issues as automation and genetic engineering. He noted that this heightened recognition could influence the nature of curriculum change by highlighting society's need for a changing view of technology. This viewpoint is embodied in those types of technology education that focus on problem solving and the need to draw on knowledge and skills from a range of disciplines.

Solomon [9] summarized that the STS movement is not only aimed at providing future citizens with authentic real-world issues, it also intends to challenge students' engagement in science and technology by learning socio-scientific issues and by participating in making informed, responsible decisions, based on scientific knowledge. For more than two decades proponents of the STS movement have advocated for the integration of science, technology, environment and social issues in science curricula claiming that there is no such thing as "pure science" and that science education should consider the way scientific investigation is subject to social, environmental and political considerations and contexts. Therefore, a major objective of an STS curriculum should be to give students knowledge about the science/society interface and further, to give them the ability to make decisions about science-related social issues.

In the US, the publication of the National Science Standards [10] layed out a similar vision for *Science and Technology* education described as follows:

> The science and technology standards … establish connections between the natural and designed worlds and provide students with opportunities to develop decision-making abilities. They are not standards for technology education; rather, these standards emphasize abilities associated with the process of design and fundamental understandings about the enterprise of science and its various linkages with technology …
>
> The (science and technology) standards call for students to develop abilities to identify and state a problem, design a solution--including a cost and risk-and-benefit analysis--implement a solution, and evaluate the solution …

In contrast, the standards related to *Science in Personal and Social Perspectives* state:

> (Another) important purpose of science education is to give students a means to understand and act on personal and social issues. The science in personal and social perspectives standards help students develop decision-making skills. Understandings associated with (the standards) give students a foundation on which to base decisions they will face as citizens …

However informed, the policy of describing science and technology standards as distinct from other (related) personal and social standards implies that these considerations should not be linked and that judgments related to personal values or political contexts are not required in the development of STS decision making skills. For example, Kumar and Berlin [11] related in their analysis of STS themes in US State science curricula that out of 25 state curricula analysed fully 88% percent had implemented the *Science and Technology* [10] standards described by AAAS while a substantially lesser percentage had implemented the *Science in Personal and Social Perspectives* standards. One of these standards *Environmental quality* had been implemented in under 50% of jurisdictions studied. Table **1** outlines the standards for

Science and Technology as distinct from those of *Science in Personal and Social Perspectives* listed in Table **2**.

However well intentioned, in the U.S. example, I assert that STS problem-based approaches have become over-structured in their implementation and can often communicate (implicitly) that science and technology are seen as potential solutions to social or environmental problems (see Tables **1-3** for examples). As a result of this inherently *technocentric* focus STS curricula are seldom critically examined for their own underlying values and dominant (hegemonic) practices. While this outcome is not what the proponents of STS frameworks would have envisioned - this is often what has translated into practice according to current educational policy and the viewpoints of practicing teachers who work on a daily basis with these curricula.

A more humanistic or *socially* influenced vision for STS curriculum calls on students to instead communicate effectively with others in the process of decision-making *within* the context of complex social and scientific issues. Aikenhead [12] suggests that students need to learn to ask questions, obtain evidence, understand characteristics and limitations of scientific evidence identify value positions or ideologies of both sides and have access to appropriate social criteria for judging credibility of scientists. Due to the fact that values are a constant feature of decision-making, Aikenhead relates that there is much evidence that students often give higher priority to values, common sense and personal experience than to scientific knowledge and evidence.

To many STS advocates, the highest goal of STS education would be in social action or activism (at the local level). Students should have the ability to identify science-related social issues, analyze the context in which the issues are played out in society, know the key individuals and groups involved in making decisions, and then be permitted to develop their own attitudes and be ready to act. Nevertheless, teachers' notions of loyalty to the content area or to "pure science" is often challenged by such "issues-based" STS programs. As teachers struggle with the inclusion of diverse ethical, economic and political issues in the classroom they often revert to more traditional knowledge transmitting methods in their teaching [12]. Therefore, the social intentions of the more humanistic forms of STS curricula are often not fully realized.

DEVELOPMENT OF THE *STSE PERSPECTIVE*

As discussed in the previous section, the development of science curricula that attempt to address the characteristics of more humanistic forms of science education while also addressing social interactions *within* and *among* scientific and local communities are historically based on STS ideas. However, these considerations have also been critically examined within the domain of environmental education. Environmental education in most countries is not mandatory or part of the core curriculum for schools. So, in response to these criticisms, a humanistic vision for an STS framework (in the US, Canada and elsewhere) was extended to include a variety of environmental issues within its scope. The resulting curriculum domain has been described as an STSE (Science Technology Society and Environment) framework.

A current example of the *STSE* focus is described in the Pan Canadian Science Framework - one of the first joint provincial project initiated under the auspices of the Council of Ministers of Education [5]. Similar to US based science standards, this document has functioned for the last decade as a guide for science curriculum reform in Canada. The framework was adopted in the curriculum development and renewal process in several provinces and its central ideas have substantially influenced the curriculum revisioning process.

Scientific literacy within the context of STSE according to Hodson [13] is not merely about knowing scientific ideas and facts or being able to participate in any form of inquiry.

Table 1. US Science and Technology Standards

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Abilities to distinguish between natural objects and objects made by humans	Abilities of technological design	Abilities of technological design
Abilities of technological design	Understanding about science and technology	Understanding about science and technology
Understanding about science and technology		

Table 2. US Science in Personal and Social Perspectives

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Personal health	Personal health	Personal and community health
Characteristics and changes in populations	Populations, resources, and environments	Population growth
Types of resources	Natural hazards	Natural resources
Changes in environments	Risks and benefits	Environmental quality
Science and technology in local challenges	Science and technology in society	Natural and human-induced hazards
		Science and technology in local, national, and global challenges

It is more about wanting to and being able to make decisions and perform actions in routine life by every community member. According to this perception, science education should be accessible to all, interesting, relevant and useful, non-sexist, multicultural, humanized and value laden.

As such, this version of an STSE focus can also be described as an attempt at developing a more humanistic form of issues-based science education at its very inception.

For example, the domain of STSE described within the Pan-Canadian framework [5] is prefaced as follows:

> 'Scientific literacy is an evolving combination of the science-related attitudes, skills, and knowledge students need to develop inquiry, problem-solving, and decision-making abilities, to become lifelong learners, and to maintain a sense of wonder about the world around them ... Students will develop an understanding of the nature of science and technology, of the relationships between science and technology, and of the social and environmental contexts of science and technology.'

Despite the intended humanistic focus of the STSE perspective in Canadian curriculum, a cursory analysis of current curriculum content in one Canadian jurisdiction reveals that while the implementation of STSE can offer a socio-historical perspective, the dominant focus remains largely on the understanding of only positive scientific connections rather than exploring how science is/has been socially constructed or how it could potentially silence a variety of voices. This understanding of science comes from a traditional (enlightenment) view of science, whereby knowledge is seen as reductive, mechanical and unified. Table **3** gives a sampling of some of the more typical STSE learning outcomes in Canada.

By extension, the view of science and environment in the current implementation of Canada's STSE domain appears to remain informed by the same epistemological (technological) focus as previous STS frameworks (in the US and elsewhere) and I would wistfully refer to this as *STSe* approach. This approach is seen as conceptually different from other types of environmental or ecological education, which instead seek to embed learning in the context of community-based problem solving or interdisciplinary learning [14]. The next section of this paper seeks to further problematise the inclusion of environmental education within such technocentric visions of STS or STSE frameworks.

PROBLEMS WITH A 'SCIENTIFIC' ENVIRONMENTAL EDUCATION

Problems with a purely scientific view of environmental education such as that related by the STS or STSE frameworks described in the previous section of this paper has been related by Bowers [15], who remarks that the terms 'environmental education' and 'science education' are increasingly seen as interchangeable. He then problematic this emerging relationship:

> "The effect of this categorization is that the other areas of teacher education and graduate education continue to ignore the connections between the values and ideas they promote and the cultural behaviours now overwhelming the viability of natural systems..,".

Table 3. Learning Outcomes from a Canadian STSE Curriculum Domain

Relevance of Science
Identify the use of … in everyday use
Relate scientific names of… to their common names
Demonstrate an understanding for the need for the safe use of ... in everyday life
Summarize the main scientific discoveries of the 19th and 20th centuries that led to the modern concept of ….
Technological Focus
Explain how scientific knowledge of … is used in technological applications
Describe the technology and the major steps involved in …
Provide examples of the use of … to improve technological solutions to …
Describe the historical development of a technology … and analyze why and how it was improved over time
Describe how understanding of... has led to the development of new consumer products and technological processes
Analyze and explain how societal needs have led to scientific and technological developments related to…
Present informed opinions on advances in …. and possible applications through related technology
Socio-Cultural Links
Describe ways in which the relationship between … and the beliefs of various cultures or nations
Evaluate the influence of the media on attitudes towards …
Analyze Canadian investments in human resources and agriculture technology in developing countries
Identify and research a local issue involving an ecosystem; propose a course of action, taking into account human and environmental needs; and defend their position in oral or written form

While inclusion of more technological and environmental concepts in science classes is seen by many as advancing current reform efforts, I assert that students exposed to this model of education are asked to understand environmental and technological issues only within prescribed or predetermined limits [16]. Environmental education of this kind is viewed as a modified 'science education,' and one that I describe as viewed through a 'technocentric' lens. Without the inclusion of an important socio-cultural component, environmental learning of this kind maintains and promotes only hegemonic beliefs and values while not addressing collateral problems relating to scientific developments. A more socially informed frame of reference on environmental learning would define environmental literacy as a complex undertaking involving scientific, economic, ethical and political perspectives and would also include a socio-cultural critique of the knowledge claims of scientists.

Environmental learning (more broadly defined) can seek to promote an understanding of scientific and environmental issues in the wider interdisciplinary context and in particular provide a model for the interpretation of curriculum in local communities. To make this happen educators must look outside the traditions of classic curriculum reform and insist on the adoption of socially relevant strategies that make scientific (and environmental) issues readily accessible to the public. For example, McBean and Hengeveld [17] while writing about climate change education practices, stated:

> "Society in general, accumulates and processes knowledge through experience, perception and intuition. Thus new information and facts are best understood and assimilated if these are placed within the context of the existing knowledge and past experience of the individual or community,".

In this effort, we science educators must make a concerted effort to include some notion of personal and community values within this discourse. Science reform efforts as described in the US and in Canada confirm that there is an increasingly popular conception that environmental education falls within a scientific epistemology which would severely limit the other forms of environmental learning which might otherwise occur. For example, the North American Association for Environmental Education (NAAEE) states that an important building block in the foundation of environmental literacy is an understanding of the natural processes and systems that comprise the environment, but in addition state that environmental literacy depends on an understanding of human processes and systems and their influence on the environment. The guidelines they propose (summarised in Tables **4** and **5**) are broader than the singular scientific view and begin with overarching ideas that are common to the search for knowledge about natural and human systems followed by more detailed standards.

To summarise, a purely 'scientific' environmental education can be seen as another case of reactive curricular change that has been dominated by technical influences. To counter the influence of Gardiner's technosphere this consideration of science and environment should instead begin on a more personal level, in effect assisting students in learning about their own community while aiding in their understandings of scientific / technological ideas relevant to their personal context. Essentially, content learning would be embedded within less abstract local contexts and would focus on defining a notion of community with sense-making activites within more personally defined (value–laden) contexts. For example, in another nearby jurisdiction, environmental learning has been described as an interdisciplinary endeavour addressing multiple themes including complexity (science outcomes) as well as other themes such as aesthetics, social responsibility and ethics, see for example BC Ministry of Education [18].

Table 4. Understanding the Environment (Adapted from NAAEE)

Basic Concepts and Approaches
The Nature Of Scientific Understanding
• Science is a social process of building understanding that is ongoing and changing.
• Scientific understanding is built and revised in certain ways.
• Scientific understanding has limits.
Unifying Concepts and Processes
• Systems.
• Interdependence.
• Change and dynamic balance.

Table 5. NAAEE Environmental Content Standards

Knowledge of Natural Processes and Systems
1. Physical processes within and among the earth's physical systems: the atmosphere, biosphere, lithosphere, and hydrosphere.
2. Individuals, populations, and communities.
3. Ecosystems -- the interactions of communities of plants, animals, fungi, protists and bacteria with the other components of the physical environment.
4. Ecosystem function (e.g., biotic and abiotic limits to growth, size, and distribution of populations, sources and importance of energy, and transfer and energy flow through living systems, cycling of water, nutrients, and materials).
5. Understanding of human dependence on the environment.
6. Understanding of humans as an ecological variable.
Knowledge of Human Processes and Systems
• Understanding of a range of aspects of environmental issues.
• Understanding of what shapes individual and group behavior toward the environment, including knowledge of different cultures' perceptions of humans and the environment.
• Knowledge of human cultural activities and their environmental influence, including the relationships between resources and societies and the environmental impact of global developments.

Adapted from National Research Council. 1996. National Science Education Standards. National Academy Press. Washington, DC.

Importantly, other scholars have too criticized STS / STSE programs for increasingly ignoring the academic debates about including more current and relevant socio-scientific issues in mainstream STS curricula (especially those encompassing controversy). However many teachers have resisted this. Hughes [19] for example found that:

> "teachers fear that extensive coverage of socioscience devalues the (science) curriculum, alienates traditional science students and jeopardizes their own status as gatekeepers of scientific knowledge".

Although the weighing of and debating about values can occur in science classrooms, and value judgment is also an emphasized skill in many STS units, there are many teachers who feel that dealing with values and moral issues should occur in the social studies or as part of extra-curricular social activities, and not in science classes [20]. However, teaching everyday relevant topics within a wider framework for environmental-science literacy might require developing ones own views and value positions especially within the context of science classes. The development of such ideas within the context of science education continues to evolve and have been describes as socio-scientific issues-based (or SSI) approaches. These are discussed in the next section.

SOCIO-SCIENTIFIC ISSUES-BASED (SSI) APPROACHES

In recent years, the academic discourse within science education has broadened from the earlier STS/STSE views of scientific and technological issues to include a discussion of how science and societies share a more complex interdependence. This dialogue at once acknowledges that scientific research agendas are frequently based on the perceived needs of society. However, it also acknowledges that in other instances, the pursuit and development of science helps shape and influence the development of social norms. A case in point may again be found in molecular genetics and genetic engineering, which illustrates the multifaceted interdependence of science and society. For example, basic biochemical research on DNA has made it possible for science and society to consider the possibility of altering heredity. However, perceived social needs such as the desire to eliminate disease or improve agricultural productivity have led scientists to develop techniques for harvesting stem cells and genetically modifying organisms. As a result, these technologies have given rise to a host of ethical quandaries as well as having presented new social norms with which society must now struggle and for which there is no clear technological solution [21].

The issues that evolve from the complex interactions of science and society have been termed socio-scientific issues (SSI). Socio-scientific issues can be particularly difficult for individuals to negotiate, in part, because they deal with open-ended, ill-structured problems which are typically contentious and subject to multiple perspectives and solutions. While STSE-based curricular approaches do attempt to deal with such ill-defined problems by including social issues in the consideration of scientific/technological problems, this largely occurs within 'politically acceptable limits' [16].

Recent conceptualizations of socio-scientific curriculum distinguish it from previous approaches such as the STS/STSE perspectives which tend to focus on the impact of science and technology, and typically do not consider the ethical and moral implications that underly these issues. A socio-scientific issues (SSI) approach arises from an alternative framework that unifies the development of moral and epistemelogical orientations of students and considers the role of emotions and character as key components of science education [21].

Zeidler, Sadler, Simmons, and Howes [22] have suggested that the Socio-scientific Issues (SSI) movement should replace STS, claiming that while STS education typically stresses the impact of decisions in science and technology on society, it avoids deep engagement with ethical issues and does not consider the moral development of students, they state:

> Traditional STS(E) education as currently practiced only "points out" ethical dilemmas or controversies, but does not necessarily exploit the inherent pedagogical power of discourse, reasoned argumentation, explicit NOS (nature of science) considerations, emotive, developmental, cultural or epistemological connections within the issues themselves.

Tal and Kedmi [20] soften this critique by stating that within STS(E) frameworks, teachers must acknowledge that for students to develop scientific literacy that is founded on open debates of controversial issues, they need to adopt a more realistic view of science and its potential for resolving conflicts than is currently common in the STS(E) approach. In addition, they must practice different approaches in class that encourages thinking and enables dialogue and discussion of problems that may not necessarily have scientific or technological solutions.

The developing discourse around SSI is promising for science educators as it leaves behind the hegemonic conditions embedded within earlier STS and STSE perspectives, and provides room for marginalized voices in the dialogue of how to deal with the troubling environmental issues faced by the broader society. The open-ended nature of SSI problems also allows room for a broad range of interpretations, offering opportunities for localizing and interpreting curriculum related to scientific, technological and environmental developments. In short, the SSI approach may allow for a more ecological and inclusive framework for both science and environmental education, one that can also acknowledge the importance of context and the broader community in its consideration of real-world problems.

ECOLOGICAL FRAMEWORKS: LEARNING 'IN' COMMUNITIES

Ecological frameworks apply the principles of Ecology -- derived from the Greek oikos (or household) to an examination of the relationship of all living things with their environments and with one another as living and interdependent systems. In a philosophical sense, ecological notions such as community or complexity also apply to our conception of the human-world relationship and to the theory and practices of education. Ecological frameworks aim to build on a specific understanding; that humankind is an interconnected part of both the human and natural worlds.

Further, to understand ecologically is to make sense of the human world as part of, not apart from, nature; it is to understand humankind's "implicatedness in life" [23, 24]. Therefore, understanding ecologically also has an emotional core: One's knowledge about ecological processes and principles is made meaningful and personal due to an emotional attachment to the world and its living communities [24].

My consideration of an inclusive, *ecological* framework for science education at once responds to a critique of a mainstream organization of curricula by providing for alternative issues-based and place-based pedagogies, while also allowing teachers to interpret curriculum in ways that refocus learning 'on' and 'in' communities. A recent example of this type of framework applied to diverse curriculum can be seen in the earlier described British Columbia model [18] whereby environmental learning outcomes are spread across a broad mix of disciplines inclusive of science. An example of this integrated approach is presented in Table **6**.

Teaching within an ecological framework focuses energies on the importance of quality of *life within communities* while assisting students in the development of a sense of place within them. While others have made arguments for place-based or community-based models of learning, I attempt to take this view further by describing the need for critical and embodied approaches in its implementation. Central to this is the idea that ecological frameworks for education recognize that our assumptions about effective teaching are best enacted when actions are deeply embedded within the complexity and authenticity of real communities.

The notion of a place-based education has been well described by Sobel and related ideas have been expanded on by others [23, 26-30]. The idea of place-based learning connects theories of experiential learning, contextual learning, problem-based learning, constructivism, outdoor education, indigenous education and environmental education. In defence of what he describes as a *critical pedagogy of place*, Gruenewald writes that our educational concern for local space (community in the broad sense) is sometimes overshadowed by both the discourse of accountability and by the discourse of economic competitiveness to which it is linked [23]. In my opinion, place becomes a critical construct to its opponents, not because it is in opposition to economic well-being, but because it challenges assumptions about the dominant 'progress' metaphor and its embedded neo-conservative values.

An ecological framework breaks from this mold by taking as its first assumption that education is both *about* and *for* the community. Ecological conceptions of education place an emphasis on the inescapable *embeddedness* of humans and their technologies in natural systems. Rather than seeing nature as 'other', ecological education involves the practice of viewing humans as one part of the natural world, where human societies and cultures are a product of the interactions between our species and the places in which we find ourselves [31]. Such an approach also negates issues of 'right' or 'wrong' and allows individuals or groups to consider multiple perspectives on an issue or problem, thus allowing the relevant socio-cultural critiques of issues to be placed alongside scientific considerations. Such frameworks also seem congruent with the socio-scientific, issues-based approaches to science and environmental learning described earlier.

Table 6. Selected Environmental Learning Outcomes (Grade 7)

Science
• analyse the roles of organisms as part of interconnected food webs, populations, communities, and ecosystems
• assess survival needs and interactions between organisms and the environment
• assess the requirements for sustaining healthy local ecosystems
• evaluate human impacts on local ecosystems
• explain how the Earth's surface changes over time
Social Studies
• analyse the concept of civilization as it applies to selected ancient cultures
• identify influences and contributions of ancient societies to present
• assess ways technological innovations enabled ancient peoples to adapt to and modify their environments
• assess how physical environments affected ancient civilizations
• identify the impact of human activity on physical environments in ancient civilizations
Fine Arts
• select a means of communication to express ideas and emotions in dramatic work (drama)
• identify distinctive characteristics of images from a variety of historical and cultural contexts (visual arts)
• create images that convey beliefs and values, and incorporate the styles of selected artists from a variety of social, historical, and cultural contexts
• demonstrate an understanding of safety and environmental considerations in the use of materials, tools, equipment, and processes
• use and maintain materials, tools, equipment, and work space in a safe and an environmentally sensitive manner
Personal Planning
• identify skills that are transferable to a range of school and recreational situations (e.g., time management, teamwork, problem solving, communication, adaptability)
• analyse factors (including media and peer) that influence personal health decisions

Adapted from the Environmental Learning and Experience (ELE) Curriculum Maps, BC Ministry of Education (2008).

The concept of an ecological model lies at the nexus between a 'science education' which emphasizes particular forms of knowledge construction conceived of and implemented outside of 'authentic' communities, and an 'environmental education' which juxtaposes this knowledge with other socio-cultural and values based constructs which could be described as an environmental ethic. It is my assertion that ecological principles can be mapped onto a more holistic model, which allows science education to flourish within a more inclusive framework. One that allows standardized curriculum to be 'interpreted' for local socio-political conditions. The framework embeds elements of 'sociosphere' and 'technosphere' within the realm of the 'ecosphere.' The model also assert the ecological notion of 'place' having primacy in the interpretation of formal curriculum. This adaptation of the model is presented as Figs. (**2**, **3**).

The interrelationship of Gardiner's spheres of influence

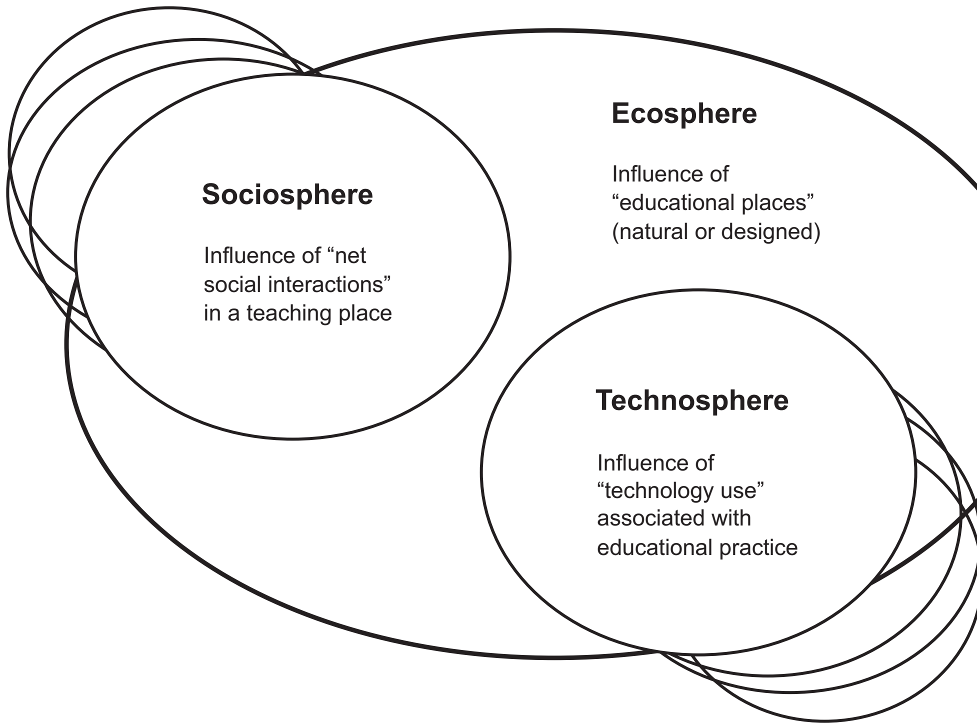

Fig. (2). A reinterpretation of the change model.

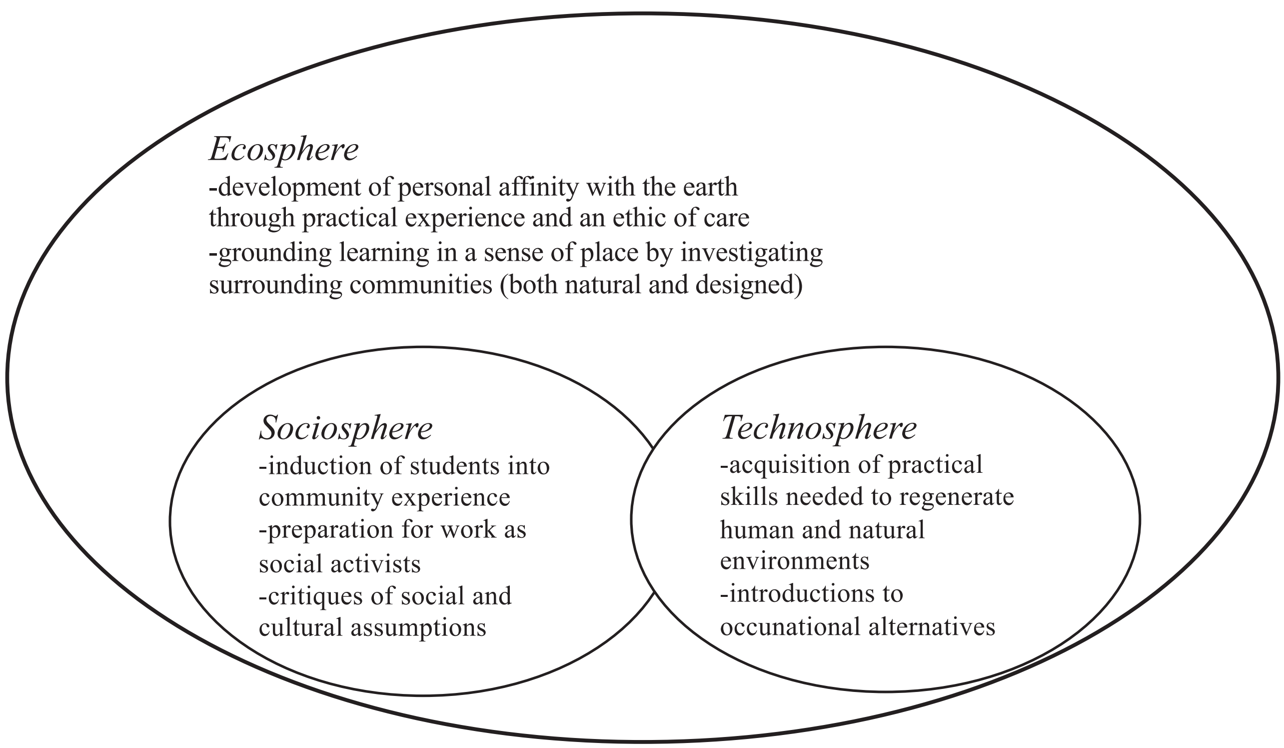

Fig. (3). The model adapted to an ecological framework.

form our developing view of 'community' as the net influence of social interactions and associated technologies embedded in the proximity of particular places (or *islands*). A detailed qualitative description of this ecological approach to curriculum has been described elsewhere [32]. However, the defining feature in this model, is that ecosphere (in this case relating to natural or designed environments) is given prominence and the tacit acknowledgement is made that the other spheres arise primarily out of this sphere of influence. The sociosphere and technosphere influences are thus limited by their (geographical) congruence in the model. The curriculum is thus interpreted as a guide to solve relevant socio-scientific issues as they arise within distinct communities [32].

An 'Island' Metaphor for Community

We have chosen an island metaphor to communicate this framework for a variety of reasons. Islands are a powerful metaphor in everyday speech as well as in several academic disciplines and we use them here primarily as an attempt to clarify our meaning of community. Importantly, beyond the metaphor, islands have played a major role in the realm of knowledge construction, for example, descriptions of isolated gene pools in the Galapagos archipelago were seen as instrumental in the development of Darwinism as a scientific theory and these same processes can be described as part of the micro-evolution taking place on many islands. Social anthropology also uses islands implicitly in the description of isolation and boundedness in cultural systems [33].

Geographically speaking, islands can be said to be mountains that emerge from the bottom of the sea to tower above the water. Lehari [34] writes that the structural similarity of the phenomenological order between such types of landscape as an island in the middle of the open sea, a mountain in the middle of an open country, or an oasis in the desert allows for the similarity of metaphorical meanings for an island, mountain or oasis. The precondition of an island's metaphorisation is its existence in environmental experience. Put simply, an island is not an island until you *go there*. Once you are there, an island becomes closed in both a temporal and spatial sense because the obstructed movement away from the island considerably changes the temporal structure of island life. The relation between outer and inner, working and free, everyday and festive, physical and mental time is different 'on island' [34].

The island metaphor retains our most basic relation with nature because its limits are clearly defined and we 'see' where community might begin and end. Still, an island can be characterized as having what Lehari terms a 'closed openness.' The phenomenon of 'island' is created by an essential ambiguity of environment, wherein individuals experience a dual place identity [34]. The basis of this paradox is the opposition between the experiences of sight and body. While you can 'leave' the island in the physical sense by boat, ferry, or raft, the coastal water line is the border for a walker, whereas the border for the viewer is on the horizon. An islander (when they are on the island) has the experience of two simultaneous borders.

The act of 'visiting' an island in both a literal and metaphorical sense is seen as an enhancement to our ecological framework and as the most essential tool for community engagement. The model also blurs the lines among Gardiner's spheres of influence though it is clear that the realms of technosphere and sociosphere are clearly embedded within our island ecology (ecosphere).

Finally, the dominant principles which inform the work of science educators subscribing to this type of ecological framework might include:

- development of students' personal affinity with the earth through practical experience;
- grounding learning in a sense of place by investigating surrounding natural communities;
- induction of students into community experience - countering a press towards individualism;
- acquisition of practical skills needed to regenerate human and natural environments;
- introduction to occupational alternatives that contribute to the preservation of local cultures;
- preparation for work as activists able to negotiate structures/policies supporting social justice;
- critique of cultural assumptions upon which modern industrial civilization has been built.

I assert that these principles should be mapped onto the holistic framework (adapted from Gardiner) to allow both the STSE and environmental learning perspectives to flourish within a more inclusive framework. Early success with this model has been met in the development of teacher professional development activities in a number of contexts. In my experience, the model is particularly effective with *island* communities where the boundaries of the community (physical and social) are quite distinct - and where the framework is applied in specific ways. Continuing research will involve the development and description of diverse case studies to inform the development of multiple and overlapping ecological models for the localised interpretation of curriculum. If we are successful, we will have a place based science curriculum which will be responsive to the variety of geographically and socially distinct communities where we endeavour to make our work culturally meaningful and relevant.

CONCLUSION

A critique of the STS and STSE curriculum reform efforts within science education reveals that the inclusion of environmental learning topics often only stress scientific and technical information, and that teaching within a 'values free' context is problematic for both science and environmental education. The concept of an ecological model lies at the nexus between a 'science education' which emphasizes particular forms of knowledge construction conceived of and implemented outside of 'authentic' communities, and an 'environmental education' which juxtaposes this knowledge with other socio-cultural and values based constructs which could be described as an environmental ethic.

I assert that students should instead consider multiple values-based views about environmental issues (including the scientific perspective) in the context of a localized and inclusive ecological framework. Such a framework allows students to develop valuable socio-cultural skills and cognitive attributes through exposure to real-world problems grounded in the experience of local, social and ecological environments. There is also a need for pedagogical undertakings that promote reflection on past and present social beliefs while supporting opportunities to learn about and take part in political change in their communities. The ecological framework proposed here illustrates what this might mean for the local interpretation of curricula. Further development and dialogue on these important issues is required in order to explore the complex nature of including scientific, environmental and social issues within formal science curricula.

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