GETTING BACK TO THE REAL WORLD: CREATIVE APPROACHES TO SCIENCE LITERACY, PROBLEM SOLVING AND CULTURAL INQUIRY

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Abstract

Today, STEM and/or STEAM frameworks dominate the discourse around science education and what constitutes a ‘scientific’ literacy. While no one definition prevails in the literature, this literacy is often defined in the context of a current national concerns and focuses largely on Eurocentric (western) models of science and/or scientific knowledge in terms of concepts, models, theories, or principles. As it currently stands, the term STEM is mostly used when addressing educational policy and curriculum choices in schools, aimed at improving competitiveness in science and technology with implications for workforce and economic development (often with some missing voices from women and Indigenous communities). Without an important socio-cultural critique, education of this kind can maintain and promote hegemonic beliefs and values while ignoring collateral problems relating to scientific or technological development: many of which have been linked to social and environmental injustice. In this paper, I offer three perspectives in an effort to decentre the discourse around the STEM movement. Using the overlapping themes of biocultural diversity, Two-Eyed seeing and guided inquiry, I offer suggestions on how to reframe science education as an interdisciplinary practice centred on student and community needs. In these ways, science education can ‘get back to the real world’ and promote creative approaches to science literacy, problem solving and cultural inquiry.
Introduction and Background

In contextualizing this paper which I have been invited to share, I preface it by saying that I don’t do not view myself, or my work as being centered in a traditional model of science education ‘per se’ despite a formal training in the discipline. I am also not a big fan of the STEM or STEAM acronyms with accompanying frameworks that are now dominating the discourse around science education. However, having stated this bias clearly, perhaps this stance is a good perspective to take in a special issue with the stated aims of “disrupting and decentering dominant teaching practices in science education.” To make this point clearer, I have titled this paper: Getting back to the real world: creative approaches to science literacy, problem solving and cultural inquiry.

To begin this argument, I note that the concept of ‘science’ literacy has been an important component of education reform agendas worldwide for some time, and while no one definition of scientific literacy prevails in the literature, it is often defined in the context of a current national concerns and focuses largely on Eurocentric (western) models of science and/or scientific knowledge in terms of concepts, models, theories, and principles that all students ought to know, understand and use. However, this definition does not address diverse audiences’ (especially women and minorities). Roth and Barton argued 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).

Common usage of the ‘STEM’ acronym to describe the current round of curricular reforms arose shortly after an interagency meeting on science education held in the U.S. in 1998 by the National Science Foundation (NSF). At that meeting, after first expressing some discomfort for the older acronym (METS), the NSF instituted the change to the current, more popular acronym. As it reads now, STEM aims at integrating outcomes and skills related to its constituent elements or disciplines, namely: Science, Technology, Engineering and Mathematics. Since that time, the STEM designation has been applied broadly to a variety of projects and programs worldwide.

Since STEM was first conceived, there has been increasing momentum, funds and energy aimed at implementing ‘integrated’ models of STEM education in schools. These integrated models typically refer to at least two or more of the discipline areas being applied together to solve problems or to make/design products. However, despite publicity around the reforms, and the substantial amount of funding available, it is still prudent to ask if STEM education (alone) is capable of achieving the outcomes that are expected of it (Zandvliet, 2018). What are the overarching goals of the STEM movement? What other efforts will be needed to ensure its success?

In many countries, STEM innovations are considered by national governments to be the key to obtaining a global, economic future and so, 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 the literally billions of dollars in
expenditure, the early results have been mixed. Simply put, 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 (2015) stated that this problem lies with the E of STEM noting that *Engineering* is not a subject in public schools. Despite this, others have suggested that the E in STEM might equally represent an E for *Economy*, as the growth in STEM innovations is seen as a way forward to securing a strong economy with highly capable workers for the future (Chubb, 2015, Zandvliet, 2018).

Blackly and Sheffield (2015) argued earlier for another type of E for STEM – possibly that of E for *Ethics* or even an E for *Environment* as possibly more appropriate visions for science education reform. From the perspective of the reform movement, and for new models of teaching and learning, it is indeed feasible that scientific, technological or environmental topics form a more authentic context for learning, thereby making science content more meaningful to students. In turn, this might facilitate deeper understanding of the subject matter: a key goal of current reform efforts in science education. Still, within a largely economically motivated STEM model – ‘environmental’ or ‘cultural’ topics are most often reduced to the simple transmission of knowledge (Sammel and Zandvliet, 2003).

Another movement can be found in the evolving STEAM framework. This 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 (see Figure 1). STEAM projects are considered to be science-based, but also incorporate artistic expression. Advocates for this approach argue that this will produce students who take risks, engage in experiential learning and persist in problem-solving. Many science educators are not convinced that adding an *A* to STEM is beneficial. In fact, some critics see it as a dilution of STEM’s focus and objectives. These advocates for STEM caution against expansion to STEAM arguing that while it may be beneficial for students to have exposure to the arts, those pushing it are considered external to the STEM community.

**Figure 1: A play on words**
As it currently stands, the term STEM is mostly used when addressing educational policy and curriculum choices in schools, aimed at improving competitiveness in science and technology with implications for workforce and economic development. In this, I must echo my earlier critique of science education reforms 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 other important concerns for social and environmental justice take a distant second place to the demands of international competitiveness (Zandvliet, 2018).

Without an important socio-cultural critique, education of this kind can work to maintain and promote hegemonic beliefs and values, ignoring collateral problems relating to scientific or technological development: many of which have been linked to social and environmental injustice. Still, this critique is not about condemning all 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 the Western traditions of science or indeed, what it means to be scientifically literate.

**Biocultural Diversity as a ‘Provocation’**

Moving on from the critique of the STEM / STEAM movements, I’d I would like to offer a simple provocation towards another view of contextualizing science education. In the past I have argued for a more inclusive, ‘ecological’ framework for science education (Zandvliet, 2010). Put simply, this connotes an emphasis on the inescapable ‘embeddedness’ of human beings and their technologies in natural systems, instead of considering nature as the ‘other.’ Ecological frameworks view the human enterprise as one part of the natural world and human societies and cultures as essentially an outgrowth of interactions between our species and particular places (Smith & Williams, 1999). Such an approach to science education would also allow educators to consider multiple perspectives on an issue or problem. This line of inquiry eventually took me to consider more deeply the concept of ‘biocultural diversity’ as central in my work (Zandvliet et. al. 2023).

Biocultural diversity as defined by Maffi (2007) can be described as ‘the diversity of life in all its manifestations: biological, cultural, and linguistic — which are interrelated within a complex socioecological adaptive system.’ Maffi further relates that this diversity is made up not only of the diversity of plants and animal species, habitats, and ecosystems, but also of the diversity of human cultures and languages. While positive correlations have been described between biological diversity and linguistic diversity (for example), my research has focused more centrally on social factors such as educational/cultural practices, as these have been found to uniquely influence biocultural diversity.
It is important to note that the concept of bio-cultural diversity is dynamic in nature and takes the local values and practices of different cultural groups as its starting point for sustainable living. For educators, the issue is to work to preserve / restore important practices and values, but also to modify, adapt and create diversity in ways that resonate with diverse urban and rural communities. In this research, bio-cultural diversity is conceived as a reflexive and sensitizing concept that can be used to assess the different values and knowledge of all people – as a reflection on how we live now and in the future with biodiversity. As such, the concept must also be closely tied to issues of teaching and learning.

This type of research also gives attention to issues of power or privilege (using a critical pedagogy stance) as these are mediating factors within the education milieu – particularly with reference to government mandated curriculums and teacher training practices. As Donald (2019) frames it, “the origin of current human struggles to balance the desire for economic development with ecological sustainability derives from a deep forgetting of…simple truths” (p.104). Biocultural research and practice aim to deeply describe the simple truth of our inter-relatedness and interdependence.

The notion of bio-cultural diversity is also related to the Indigenous concept of land as first teacher. Positioning ‘land’ as a source of knowledge brings into focus the importance of this relationship. As Michell (2018) phrased it, “we are the land, and the land is part of us. We are the context…When one aspect of nature is out of balance, all forms of life are affected” (p. 17). Beyond considerations inter-relatedness, the concept of land as teacher also implies responsibility. To acknowledge that we belong to the land means we also have a duty to maintain good relations with it. For Styres (2011), “when land informs reflective practice, pedagogy and storying, everything starts with and returns to the land, self is not/cannot be set apart from the interconnected and interdependent relationships embodied in land” (p. 718).

So now, what would such a biocultural framework look like in practice? To introduce this idea, I offer up a short case study of some curriculum pieces from my on-going work with student teachers in the context of Haida Gwaii. The coursework is offered as an intensive 2-3 week2–3-week series of field experiences set in the community of Skidegate (Education 452) and the following vignettes are excepted from a collection of case studies recently published in a volume of Indigenous science education research and resources (Alsop et. al., in press).

**Case Study: Haida Gwaii**

*When Xā’gi emerged from the waters, Foam-Woman was sitting upon it. Around the edges of the reef were other supernatural beings, but she permitted none of them to come near. If anyone attempted it, she looked at him and winked her eyes, when lightning shot forth and drove him back. From this she was also called She-of-the-Powerful-Face. When Djila’qons [Jiila Kuns], the grandmother of the Eagles, approached, Foam-Woman said, “Keep away from here before I look at you;” and when she did look, Djila’qons “went down.” Others say, perhaps out of respect*
Scientists believe that many glaciations have occurred on Haida Gwaii and geological evidence of the most recent (Late Wisconsin Glaciation) is most commonly found. Even at the glacial maximum, some scientists believe that northeast Haida Gwaii and parts of the Hecate Strait remained ice-free. After the glacial maximum was reached, the global climate shifted dramatically, resulting in the melting and rapid retreat of ice. Scientists believe human migration to Haida Gwaii (and down the coast of British Columbia) occurred during these ice-free periods, somewhere between 15,000 and 10,000 before present.

[excerpt from a science lesson]

Figure 2. Location and features of Haida Gwaii

The above accounts are also excerpts from scientific, cultural exhibits displayed at the Kay Llnagaay Heritage Centre (Kay) in Skidegate and are referenced in the unit and lesson plans developed by SFU teacher education students. These writings form part of a unique and evolving educational experience on these islands located on the westernmost fringe of British Columbia forming part of the Pacific Rim. Texts such as these describe important aspects of a community unique in Canada for its connections between culture, ecology and the land. For these reasons, it is the location for a longstanding environmental education program offered in a collaborative partnership between the Haida Nation and SFU’s Faculty of Education.
Science and Story

It [Xā’gi] came to the surface like a reef in the falling tide. On top of it a woman called Foam-Woman was sitting, and the families of supernatural beings swam over to it from all sides. Only those were there out of whom the present island families were going to come. Before this, when it was not yet on the surface, and the supernatural beings tried to climb on top of it, Foam-Woman refused to allow them to [let them out of the water]. Then they were afraid, and waited for it to come above the surface of the water, as she had said. When quite a piece of it was above the surface, they began to talk over where they were going to settle ... 

[Swanton 1905a:p76]

Scientists who study the geology of Haida Gwaii generally separate the islands and the surrounding marine area into two regions: the Queen Charlotte Ranges and Coastal Trough, including the Hecate Depression. These mountains run from southwestern Graham Island to Moresby Island and include the Skidegate Plateau. While the Queen Charlotte Ranges form the backbone of the islands, they are extremely rugged. The Coastal Trough is a marine area between the east coast of Haida Gwaii and the west coast of the British Columbia mainland. 

[excerpt from a science lesson]

The survival of many elements of First Nations’ Traditional Ecological Knowledge (TEK) despite the effects of Western expansion and policies such as forced resettlement, mission schooling, the outlawing of traditional practices such as: curtailing of traditional legal actions through banning of potlatches, underscores the strengths of these cultures and their continuity from past to present (Wilson et. al. 2005). For many First Nations such as the Haida, oral records form an integral element of their culture and are seen as key to their identity as people. These traditions can also provide a link to the past that is an important affirmation of the community in a Western-dominated world. Therefore, oral traditions are seen as a valid interpretation of the past and social relevance for the living.

Increasingly, anthropologists look at oral histories not as mere myth but as tools to unlock high-level cultural constructs or as illustrations of theories (Wilson et. al. 2005). In many parts of the world, oral history can be shown as an account of the past of a nation, that contains accurate information about past events or the past environmental actions. Anthropological research has demonstrated a connection between oral histories and pre-historic events. On Haida Gwaii, Swanton (1905a, 1905b), documented many oral histories with a deep time depth describing a time when Haida Gwaii was joined to the mainland, a time when the climate was much warmer, a time when it was cold, and a time before the first trees (Wilson et. al., 2005).

Many more cultural accounts now exist in written and recorded forms and still in the memories of Haida elders. These show the connection between the Haida and their land and give an idea of their length of inhabitation of these islands. Stories preserve information about the ancient past that cannot be obtained from Western sources, but they also store other important kinds of knowledge (eg. medicinal knowledge or environmental management practices). They
also ‘give roots’ to young people and instill pride in their connection to Haida Gwaii. This kind of understanding may assist us in moving towards a more sustainable relationship with the environment. This point also connects to another important development: the re-emergence of Indigenous forms of education (Lowan–Trudeau 2013).

**Two-Eyed Seeing as an emergent practice.**

The previous case study set as it was in the context of an Indigenous community (on Haida Gwaii) offers insights into the need to be more inclusive in the forms that science education curriculum may take in the future. Worldwide, there is a need to more deeply incorporate First Nations perspectives into the K-12 curriculum. This is due partly to influences such as the UN Declaration of the Rights of Indigenous Peoples (UNDRIP), which states that educators have a professional obligation to ensure the rights of all Indigenous peoples, and to include First Nations perspectives in their teaching (UN, 2007). This agenda requires a transition from colonial education systems to postcolonial and globalised approaches that recognize the importance of the knowledges and wisdom of Indigenous peoples and local communities (Anderson & Rhea, 2018). Countries such as Australia, Canada, and New Zealand have enacted policies through their teacher qualification standards and curricula that require educators to understand and include First nations ways of knowing and being to support reconciliation (e.g., Australian Institute for Teaching and School Leadership, 2022).

Further, according to the OECD (2020), *science identity* is also strongly linked to social justice, and is considered to be fundamental to science learning and achievement, perhaps as important as acquiring the knowledge and competencies of science. This concern stems from the question: “How can science teachers enable all students to study a Western scientific way of knowing and, at the same time, respect and access the ideas, beliefs, and values of non-Western cultures?” (Snively & Corsiglia, 2001, p. 24). Addressing this requires a recognition that “all science learning can be understood as a cultural” (National Research Council, 2012, p. 284), here, culture is reflected in peoples' and communities' identities through their ways of being, knowing, and relating to the world. Finally, teachers need to understand and support their students to engage in and through multiple ways of knowing (Bang & Medin, 2010) while recognising the potential for common ground.

This leads me to consider the idea of *Etuaptmumk* or *Two-Eyed Seeing*. This concept is based on the idea that both Indigenous and Western scientific ways of knowing are valuable, achievable, and can inform how we live in the world (Bartlett et al., 2012; Hatcher et al., 2009). This idea originated from Atlantic Canada in the traditional territory of the Mi’kma’ki people who have the longest Canadian history of living with colonizers, thereby providing their Elders with a unique understanding of Western perspectives (Hatcher et al., 2009). The Mi’kma’ki word *Etuaptmumk* means *the gift of multiple perspectives*. In 2004, the phrase *Two-Eyed Seeing* was coined by the Mi’kma’ki Elders Albert and Murdena Marshall, while working in collaboration with Professor Cheryl Bartlett (Bartlett et al., 2012).
In explaining the significance of Figure 3, the Elder (Albert) wrote: “the two jig-saw puzzle pieces help remind us that, with respect to [traditional knowledge], no one person ever has more than one small piece of the knowledge” (Bartlett et al., 2012, p. 336). Further, other pieces of the puzzle include the perspectives of different cultures, other living beings, and kin. This ‘binocular view’ supports a deeper, more generative field of view than would be achieved by either perspective in isolation (Iwama et al., 2009) Essentially this results in a richer understanding of the world (Roher et al., 2021).

Two-Eyed Seeing recognizes that both Indigenous and Western knowledge systems are whole and distinct in and of themselves (Roher et al., 2021). On either side of this model, knowledge holders are not asked to relinquish their position; instead, they work collaboratively across knowledge systems on a common problem to understand perspectives from both sides (Berkes, 2017). Avoiding false dichotomies, the model also assumes that both systems contribute to co-produce a pluralistic understanding that informs context-specific decisions that add to our understanding of the world (Bang, & Medin, 2010).

Within the model of Two-Eyed seeing, both systems offer valid, yet different understandings that act in tandem to create unique knowledge or innovations (Mistry & Berardi, 2016). The model also actively considers common ground, so that “Indigenous knowledge systems can be paired with revelatory Western scientific insights” (Reid et al., 2021, p. 245). Importantly, the model acknowledges the changing nature of knowledge systems from within our own perspectives. At Cape Breton University, Two-Eyed seeing was first applied to guide the development and implementation of an Integrative Science concentration within a four-year Bachelor of Science degree program for Indigenous students (Hatcher et al., 2009). The term integrative denotes the bringing together of knowledges and also emphasizes an ongoing process of knowledges travelling together. As a guiding principle, the model seeks to avoid knowledge domination and assimilation thereby preserving the integrity and authenticity of each knowledge system.
Key philosophies that informed the program were taken from Indigenous knowledges from across the globe, including concepts such the idea that all beings and natural elements are interconnected and interdependent (Cajete, 2000; Levac et al., 2018). In the model, humans are considered part of the natural world, albeit a very small part (Hatcher et al., 2009). Knowledge and the knowers are interconnected, and knowers bear a responsibility to act on that knowledge and this ethic of responsibility is extended to all beings—now for future generations (Bartlett et al., 2012). Since its inception, there are many good examples where the Two-Eyed Seeing approach has been applied in fields such as Education for Sustainable Development (Zeyer, 2022), fisheries (Reid et al., 2021), medicine (Hall et al., 2015), and wildlife health (Kutz & Tomaselli, 2019). In summary, the practice of Two-Eyed seeing presents some authentic and compelling possibilities for a more culturally inclusive form of science.

**Interdisciplinary Knowledge and Guided Inquiry**

Getting back to the idea of decolonizing or decentring the frameworks of STEM and STEAM that currently dominate science education discourse, it is important to note that at the core of any scientific enterprise (Indigenous or Western) is the practice of authentic and community-based inquiry. In my opinion, the practice of community-based inquiry may form the beginning of a potential ‘common ground’ that can form at the nexus of biocultural, Indigenous and Western ideas about science education. In a sense, this would essentially be about bringing education ‘back to the real world’ and getting more creative about what we mean about an interdisciplinary culture of inquiry.

Within the science education community, there has been a long-standing critique of teacher-centred approaches that are reliant on textbooks (Harlen & Bell, 2010; Osborne & Dillon, 2010). In fact, more than a century ago, John Dewey (1910, 1990) advocated for student-centred forms of inquiry. Inquiry-based teaching and learning is now thought to better reflect the practice of scientific inquiry and further refinements to this model have integrated additional discipline-specific approaches where students can engage directly in knowledge construction processes (Kenny & Cirkony, 2018). These involve teachers guiding students to create representations of phenomena (e.g., diagrams or models) and further, to use them to illustrate their ideas or justify claims (Tytler et al., 2013).

Given the long-standing calls for guided, inquiry-based approaches to education (e.g., Dewey 1910/1990; Deboer, 2006; Eberback & Hmelo-Silver, 2015; Harlen & Bell, 2010), many jurisdictions adapted a framework known as the 5Es: A constructivist model to support teachers and learners of science. First introduced in the U.S. during the 1980s, it has been adopted in many places around the globe (Bybee et al., 2006). The model scaffolds teaching and learning using five iterative phases, those of: Engage, Explore, Explain, Elaborate and Evaluate, with each having a specific purpose in helping students build their understanding with the guidance of a teacher, in contrast to more teacher centred, transmissive approaches.
The *engage* phase is intended for students to “tune-in” to a topic and make connections with their current knowledge. Here, a teacher provides experiences to probe students’ ideas about a given phenomenon. Students can express and share their ideas through various representations (e.g., diagrams, models, role plays) in combination with text or verbal explanations. In the *explore* phase the teacher prompts deeper and more scientific thinking though additional hand-on activities, or by posing follow-up questions to link the students’ explanations to new evidence, or by asking students to compare divergent explanations.

In the *explain* phase, the teacher provides more (or different types) of information to the students. The teacher provides a range of experiences to build students reasoning and inquiry skills. This can involve facilitating discussion and debate among individuals and between groups of students. Importantly, a teacher must avoid moving to an explanation too soon. To support the development of conceptual learning, the teacher also gradually introduces new ideas, to ensure students are not simply memorising content. The teacher needs to judge when students are ready for the next stage: this may be through the teacher posing questions or making suggestions that extend students’ ideas.

After further work in consolidating students’ understanding, the process shifts to the *elaborate* phase where they apply their knowledge to solve a problem or do an investigation. Students then share their ideas through a range of representational forms and challenges. This helps to build inquiry skills and representational reasoning abilities (Cirkony & Kenny, 2022). Finally, the *evaluation* phase starts at the beginning of the process: as students share their ideas, and teachers receive feedback about students’ learning. At the end of the sequence, students then demonstrate what they learned. This can include ‘representation-rich’ and interdisciplinary activities as well as more traditional methods of evaluation. Importantly, the 5Es model has also been adapted to accommodate First Nations perspectives. For example, a Canadian 7Es model is an enhanced and extended version of the 5Es, by its inclusion of the *Environment* and *Elders* (FNESC, 2016). This ensures lessons relate to the local environment to build an appreciation of connectedness and a sense of place.

The 7Es model promotes traditional ways of teaching and learning (e.g., guest speakers, guided-labs, field trips, formative assessment), and provides guidance for the development of lessons and units (FNESC p. 19). It is further supported by a framework for designing Indigenous science resources, which attempts to foreground Indigenous voices, languages, and diversity; protocols; relationships with the land; and ways of teaching and learning (FNESC, 2016). Teaching and learning in this way can involve experiential learning, storytelling, observations, visualisations, movement, students use of trial-and-error, and student directed research projects. Importantly, educators can also help to establish learning communities by experimenting with learning circles, cooperative problem-solving, and knowledge sharing without the need for a competitive ranking of performance.
As part of a culturally responsive curriculum developed earlier in the U.S., Stevens (2001) also compared traditional (Indigenous) forms of teaching with inquiry teaching (see Table 1). Here, where traditional teaching approaches involved expert knowledge placed alongside relevant and practical contexts, inquiry teaching placed teachers in the facilitators of learning and emphasized student-centred methods. Together, these offer several strategies, highlighting the opportunity to integrate diverse expertise and perspectives, learning across the disciplines, and connecting learning to relevant community contexts.

**Table 1.** Similarities between traditional (Indigenous) teaching and learning and teaching using inquiry-based methods (adapted from Stephens, 2001, p. 28 as cited in Cirkony et.al 2023).

<table>
<thead>
<tr>
<th>Traditional Teaching</th>
<th>Inquiry Teaching</th>
<th>Compatible Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can involve Elders, family, community and peers</td>
<td>Uses teacher as facilitator of learning; science is seen as a social endeavor</td>
<td>Uses community involvement, cooperative groups, peer tutoring; multiple teachers as facilitators of learning</td>
</tr>
<tr>
<td>The learning connected to life, seasons, and environment</td>
<td>Investigates fundamental science questions of interest to students’ everyday lives</td>
<td>Investigates questions related to life, seasons and the environment; considers multiple perspectives and disciplines</td>
</tr>
<tr>
<td>Students learn by watching, listening and doing; the Elder is expert</td>
<td>Practicing active and extended inquiry over time; use of print and electronic sources to help interpret or revise explanations</td>
<td>Learning is by active and extended inquiry; using multiple sources of expert knowledge including cultural experts</td>
</tr>
<tr>
<td>Teachings emphasize skills and practical application of the knowledge</td>
<td>The focus is on student understanding and the practical use of scientific knowledge, ideas or inquiry skills</td>
<td>Integrating skill development, understanding and application</td>
</tr>
<tr>
<td>The knowledge is shared through modeling, story-telling and innovation</td>
<td>The focus is on classroom communication and debate of understandings</td>
<td>Sharing diverse representations and communicating student ideas to both classmates and community</td>
</tr>
</tbody>
</table>
Conclusions and Limitations

In wrapping up this description around key ideas for decolonizing and/or decentring the current discourse on STEM and STEAM practices, I conclude by reiterating that the perspectives presented in my argument have leaned on the principles of biocultural diversity, Two-Eyed seeing and interdisciplinary forms of inquiry. All of these have important things to say about the types of pedagogy that are enacted in the realm of a more interdisciplinary or ‘ecological’ framework for science literacy.

First, the concept of bio-cultural diversity can be seen as dynamic as it takes the local values and practices of different cultural groups as its starting point. In working with Indigenous knowledge holders, the point is to work to preserve and restore important practices and values (for the benefit of all) but also to modify, adapt and create diversity in ways that resonate with both urban and rural school communities (Zandvliet et. al. 2023). In my opinion, bio-cultural diversity is a reflexive and sensitizing concept that can be used to assess the different values and knowledge of all people. As I have described in this paper, these concepts are closely tied to those of culture, and to teaching and learning.

Second, the evolving framework of Two-Eyed Seeing implies a co-learning journey as its pedagogy. In order to implement both knowledge systems, both educators and members of local First Nations communities need to walk and work together as they undertake the journey (Circony et. al. 2023). Given the place-specific nature of Indigenous knowledges, integrating First nations perspectives into classrooms also requires collaborating with local members of the community and alsoand focusing on meaningful cultural content. This involves positioning educators, students, and community as co-learners, sharing big ideas, and enacting project-based learning on issues of interest to both students and local communities. A co-learning journey also involves ongoing relationship-building, guided by the process of conversation. Only then do these connections have the potential to grow into long-term partnership between schools and local communities.

Third, interdisciplinary forms of inquiry may form a natural ‘common ground’ in bridging Indigenous and Western forms of knowledge-seeking and pedagogy. From a contemporary science perspective, a 5Es (representation-rich) approach can work to scaffold guided-inquiry by drawing on active knowledge construction methods that share common ground with traditional First Nations methods (Circony et al., 2023). Taking this idea further, other approaches have been recommended for enacting the 7Es model (FNESC, 2016), as activities often take place on the land (in Environment) and with Elders. In both examples of inquiry, the learning and assessment ideally take place at the same time with an emphasis on formative over summative approaches.
Finally, there are some important limitations to enacting the ideas summarised here. First, in considering diverse pedagogies, the design of curriculum is often seen as more or less not adaptable. School science has traditionally prescribed a single curriculum, irrespective of culture or place. In addition, science curricula are most often organised into disciplinary strands (biology, chemistry, earth sciences, physics, etc.), in an attempt to ‘cover’ a broad range of unrelated curricular topics (Schweingruber et al., 2012). Textbooks too, can tend to present a collection of information in the form of the “encyclopedic curriculum” in response to committee-influenced development teams (Schwartz et al., 2009, p. 799). Even today, textbooks often share science content that is considered by students as irrelevant to their everyday lives (Zidny et al., 2020). Even carefully designed experiments and other practical activities do not guarantee the meaningfulness of this type of activity when it is delivered in labs (Crawford, 2014). Nor do they work to enable students with the type of skills they will use to investigate topics in which are of natural interest to them.

In contrast to this limitation, Indigenous thought does not separate knowledge into disciplines (Battiste & Henderson, 2005). As one example, the Two-Eyed curriculum for the Integrative Science program at Cape Breton University went beyond the disciplinary siloes, instead following a transdisciplinary design that related to complex and socially relevant issues (Bartlett et al., 2012). Here, academic disciplines and traditional knowledge were purposely connected through the visual arts, and the body and mind through movement and dance. Further, both the content of curriculum and the forms of pedagogy used were strongly place-based, and followed a holistic education model that involved the integration of communities within the classroom (Hatcher et al., 2009).

Through the lenses of biocultural diversity, Two-Eyed seeing and interdisciplinary forms of inquiry, ultimately all students’ learning can be connected with activities that are outside of school and ‘in-community.’ This is consistent with students’ need to connect to the larger world of learning and understanding. Further, I believe that all students need to be purposefully connected to nature for these ideas to be effective. This can involve focusing on the senses and the powers of observation as important ways to help them re-establish themselves as ‘part of nature,’ a central concept within Indigenous perspectives. By designing our pedagogy and curriculum together in context, students can then develop an understanding that knowing is relational and dynamic. Only then can education ‘get back to the real world’ and allow for creative approaches to science literacy, problem solving and cultural inquiry.
References


Getting Back to the Real World


