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Embedding sacred ecology in sustainability solutions: The role of post-secondary environmental science programs

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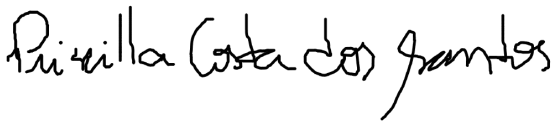

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There is increasing attention to the potential contribution of traditional ecological knowledge (TEK) to addressing an unprecedented crisis in social-ecological systems. Approaches to the bridging of scientific and indigenous knowledges thus emerge as opportune for the development of sustainability solutions. In this context, the role of academic programs in environmental science stand out for fostering collaboration across knowledge systems. In Canada, this takes place as the country pursues a reconciliation agenda where the indigenization of higher education is a contentious topic, but certain universities take the lead. This study aims at illustrating what role(s) environmental science programs inclusive of TEK perspectives can play in advancing sustainability as Canada undertakes reconciliation. The focus is on how TEK is represented in selected academic programs and what is the potential contribution of these programs' engagement in knowledge bridging to sustainability solutions. The programs studied are the late Integrative Science program offered at Cape Breton University; Trent University's Indigenous Environmental Science and Studies Program; and the First Nations University of Canada's Indigenous Environmental Science program. Through qualitative data analysis drawing on place-based environmental education perspectives that also cut across scale, results suggest that TEK is represented via ontological and epistemological pluralism associated with inclusive teaching/learning. Results also showed that the contribution of programs' engagement in knowledge bridging to sustainability solutions is expressed in action-oriented components of courses, research projects and outreach activities. A renewed environmental ethics emerging from the studied programs' experiences stands out as playing a major role in determining how relationships within and towards the environment are framed.

Keywords: Indigenous knowledge, sustainable solutions, glocality, place-based education, Canadian university, decolonization, reconciliation, environmental ethics

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What a journey MESPOM has been!

Sou biólogo e viajo muito pela savana do meu país.
Nessas regiões encontro gente que não sabe ler livros.
Mas que sabe ler o seu mundo.
Nesse universo de outros saberes, sou eu o analfabeto.

[I am a biologist and travel a lot in the savannahs of my country.
In these regions I find people who cannot read books.
But they can read their world.
In this universe of other knowledges, I am the illiterate.]

Mia Couto
Mozambican biologist and writer

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1 Introduction

In the context of global environmental challenges, increasing attention has been devoted to the potential contribution of indigenous/traditional ecological knowledge (IK/TEK) to address multiple facets of the current social-ecological crisis (e.g. Berkes 2018, Koty 2014, Leicht et al. 2018, Levac et al. 2018, Mastrángelo et al. 2019, Mistry and Berardi 2016, Rathwell et al. 2015, Tengö et al. 2017). Mastrángelo et al. (2019), for instance, performed a review of different assessments by the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services (IPBES) and found that a limited understanding of how indigenous knowledge supports ecosystem services is among the main knowledge gaps in the way of the achievement of global sustainability goals. The calls for a better understanding of indigenous knowledge to advance sustainability can be explained by interesting characteristics associated with indigenous peoples, their territories and knowledge systems. For example, in front of the current unprecedented loss of biological diversity, it is on indigenous lands that biodiversity loss occurs at slower rates (Díaz et al. 2019).

Indigenous knowledge is not without its own limitations, and its study is hampered by a number of myths about traditional peoples such as the 'noble savage/fallen angel' duality[1] (Berkes 2018). Nonetheless, scholars have elaborated on the value of IK/TEK and Western-scientific knowledge systems working together to tackle environmental and sustainability challenges, though 'together' may imply different approaches that come with associated issues. In front of the tendency of the scientific community to assimilate and appropriate IK/TEK within worldviews of managing nature, calls for collaboration and knowledge bridging attempt to minimize problems in terms of knowledge sovereignty, indigenous rights and imbalanced power relations (Berkes 2018, Koty 2014, Levac et al. 2018, Mistry and Berardi 2016, Nakata 2002, Rathwell et al. 2015, Rich 2012, Tengö et al. 2017).

The approach of bridging knowledges may take place in different contexts. Of particular interest to this study is the university context in light of the important role that higher education can play in catalyzing the transition towards sustainability (Leicht et al. 2018, Stephens et al. 2008, Waas et

[1] In this myth, indigenous peoples are seen as they should keep living as 'primitives' as doing so will prevent them from becoming "a threat to very ecosystem in which they live" (Berkes 2018, p. 250). This myth is addressed by the author by exploring the debate involving the differences between Western and indigenous conceptualizations and worldviews in terms of conservation and 'wilderness'. Berkes (2018) suggests that instead of asking whether traditional peoples are natural conservationists or not, one should inquire: 'what kind of conservation?'. For more on this, refer to Berkes (2018, chapter 11).

al. 2010). Hall and Tandon (2017), however, highlight that the contemporary university works with a very small portion of the global treasure of knowledge, thus often characterized as working with 'colonized knowledge'. Hence "the increasing calls for the decolonization of our universities" (Hall and Tandon 2017, p. 7). Pidgeon (2016), in turn, highlights that a decolonizing process is required for indigenization to occur. For her, indigenization is "a movement centering indigenous knowledges and ways of being within the academy" (p. 77). But complex issues arise when talking about indigenous knowledge as it connects to the academic domain (e.g. Hauser et al. 2009, Koty 2014, Nakata 2002, Rich 2012).

In this context, Canada is a particularly interesting case for this study because of its colonial history and recent efforts to promote reconciliation. As a component of the Indian Residential Schools Settlement Agreement[2], the Truth and Reconciliation Commission of Canada[3] (TRC), active from 2008 to 2015, called on "governments, funding agencies, universities and Canadians to undertake the ongoing work of truth and reconciliation through collaborative projects, education, research, and funding" (Levac et al., 2018, p. VIII). This work is required to include indigenous knowledge and methods – also focusing on redressing colonization – and being especially sensitive to the legacy of residential schools[4] in Canadian history (Levac et al. 2018). But Jung (2018) elaborates on numerous reasons to be cautious about reconciliation which, together with the complex issues that arise as indigenous knowledge connects to the academic domain, pose important challenges to the indigenization of the Canadian academy.

Gaudry and Lorenz (2018) found that the indigenization of Canadian universities, following the Calls to Action of the Truth and Reconciliation Commission of Canada (TRC 2015), occurs in three levels. At the first level is indigenous inclusion, "a policy that aims to increase the number of indigenous students, faculty, and staff in the Canadian academy" (Gaudry and Lorenz 2018, p.1). At the second level is reconciliation indigenization, "a vision that locates indigenization on common ground between indigenous and Canadian ideals" (p.2). At the third level is decolonial indigenization, which "envisions the wholesale overhaul of the academy to fundamentally reorient knowledge production based on balancing power relations between indigenous peoples and Canadians" (p.2). They conclude that although higher education institutions in Canada largely use

[2] This agreement " sought to begin repairing the harm caused by residential schools" (TRC 2020).

[3] For more information on the TRC's mandate and its final report, refer to http://www.trc.ca/about-us.html and https://www.rcaanc-cirnac.gc.ca/eng/1450124405592/1529106060525.

[4] Residential schools were government-funded, church-run schools set up to eradicate parental involvement in the intellectual, cultural, and spiritual development of Canadian indigenous children. Dating back to the 1870s, the last one closed in 1996 (TRC 2020).

reconciliatory language, most of them are limited to inclusion policies – what the authors characterize as the low-hanging fruit of indigenization.

While assessments of indigenization approaches occurring at universities in general may show little indication of broad transformative changes, a narrower scope allows for more detailed insights. Considering the potential contribution of IK/TEK in addressing environmental and sustainability challenges, programs in environmental science that are inclusive of consideration of IK/TEK perspectives are an important part of the dynamics on how to advance sustainability in the context of reconciliation.

Rich (2012) highlights that indigenous ways of knowing are in close association with important foundations of environmental science and studies programs in which both deal with long-term views at the core of sustainability goals, the connection between learning and responsibility, and the (healing of the) relationship between humans and the environment. Furthermore, she stresses that interest in sustainability and resilience topics leads these programs to engage in practices and activities around issues that are highly relevant to indigenous communities, "topics where these communities bring centuries of tradition to the discussion" (p. 309). For instance, Mistry and Berardi (2016) emphasize that indigenous peoples, when confronted with challenges, pursue adaptation through solutions that are holistic – i.e. aimed at increasing their resilience to various shocks and stresses from different sources. Koty (2014) asserts that the inclusion of indigenous knowledge in mainstream education fosters the strengthening of a collective understanding concerning the complexity of relationships and connections that link humans to the natural world (Koty 2014). Rich (2012) urges environmental studies and sciences programs to consider a commitment to teach not only across academic disciplines but also across different ways of knowing so that "the long-standing invisibility and exclusion of knowledges that exist outside of the Western intellectual tradition" (p. 308) is no longer perpetuated.

Therefore, the presence of IK/TEK perspectives in academic programs and, more specifically, in environmental science programs, is worth looking at since it can not only influence – and contribute to – advancing sustainability, but also takes place in the Canadian context of reconciliation. Yet, little has been explored in the sense of how inclusive environmental science programs bring about these potential contributions in terms of what sustainability solutions are influenced by – and potentially benefit from – inclusive environmental science programs, and how to approach the assessment of the influence that inclusive environmental science programs have on sustainability solutions. In summary, there is room for better understanding how consideration

of IK/TEK perspectives in environmental science programs influence – and potentially contribute to – sustainability solutions. This study aims at providing a modest yet insightful contribution in this direction.

After clarification on terminology (subsection 1.1), this study's objectives are described and introduce the guiding research questions. They explore knowledge representation in selected environmental science academic programs as well as their contribution to sustainability solutions through knowledge bridging approaches (section 2). The subsequent literature review (section 3) includes a brief overview on the aspects involved in bringing indigenous and scientific knowledges together, covering some of the frameworks for knowledge bridging (subsection 3.1). It then proceeds to explore IK/TEK in the university context (subsection 3.2) and, finally, presents a summary of some of the most recent literature on indigenization, decolonization, and the (status of the) reconciliation agenda for Canadian higher education (subsection 3.3). The theoretical framework employed, based on place-based environmental education perspectives and encompassing cross-scale implications, is further detailed in section 4. The description of the evolution of thesis approach as a result of the ongoing COVID-19 pandemic is described in section 5, which further details the qualitative methodology employed for data collection and analysis (subsections 5.1 and 5.2, respectively). Programs' profiles (subsection 6.1), how they explore local *versus* global implications (subsection 6.2), and the characterization of sustainability solutions influenced by the programs' activities assessed (subsection 6.3) compose the Results section (section 6). The interpretation of results follows (section 7), answering in detail this study's guiding questions (subsections 7.1 and 7.2 respectively). In section 8, I conclude that a renewed environmental ethics playing a major role in the programs' dynamics, although not an extraordinary finding, invites for thorough reflection not only about where the human enterprise is going but also, and perhaps most importantly, about how the journey unfolds. And more plural universities are suggested as having a role to play in this regard.

1.1 Terminology and important definitions

Considering that terminology – particularly concerning indigenous peoples – can be tricky to navigate, the term 'indigenous' is used throughout this study to encompass a variety of Aboriginal

groups. Aboriginal, in turn, includes First Nations[5], Inuit[6], and Métis[7] and refers to first inhabitants of Canada (UBC 2020).

Another term that needs clarification is 'sustainability solution'. As reported by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in the context of ESD, 'sustainable solutions' have been defined as solutions "that address society's developmental problems in economically viable and culturally acceptable ways, while at the same time maintaining or improving ecological life support systems (air, freshwater, oceans, forests and soils), rather than harming or destroying them" (Leicht et al. 2018, p. 177). The authors further explain that while sustainable solutions that are generated at the local level likely reflect particular values, aspirations and capabilities, those generated at broader settings (e.g. national or global) tend to be more generic. Focusing on IK/TEK perspectives and acknowledging its experiential component, 'sustainability solutions' are used throughout this study to refer to initiatives meant to advance environmental sustainability. There is, however, recognition that a given solution is contextual by nature and although it cannot be assumed permanently sustainable, it can be based on – and reflect – the perspectives of sustainability.

Finally, clarifications on the 'indigenous knowledge' (IK) and 'traditional ecological knowledge' (TEK) concepts are needed. Though various definitions from different scholars are available, this study adheres to propositions by Berkes (2018). For this author, indigenous knowledge refers to "the local knowledge held by indigenous peoples or local knowledge unique to a given culture or society" (p.10). He suggests that although "there is no universally accepted definition of traditional ecological knowledge" (p.4), an operational definition for the term is "a cumulative body of knowledge, practices and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (p. 8) This way of knowing is thus context-specific, "collectivized through a shared social memory, and situated within numerous interlinked facets of people's lives" (Mistry and Berardi 2016, p. 1274). As in Berkes (2018), traditional ecological knowledge is used here to refer to both the information as well as the ways of knowing (i.e.

[5] 'First Nation' is a term used to describe Aboriginal peoples of Canada who are ethnically neither Métis nor Inuit (UBC 2020);

[6] 'Inuit' refers to specific groups of people generally living in the far north who are not considered "Indians" under Canadian law (UBC 2020);

[7] 'Métis' refers to a collective of cultures and ethnic identities that trace their descent to mixed Aboriginal and European heritage (UBC 2020).

For more on terminology, refer to https://indigenousfoundations.arts.ubc.ca/terminology/.

knowledge as the thing known and knowledge as the process, respectively) and "is considered a subset of the broader category of indigenous knowledge" (p. 10).

2 Objectives

The major aim of this study is to explore how the knowledge and training present in environmental science programs that are inclusive of IK/TEK perspectives reflect in sustainability solutions, acknowledging a greater Canadian context of commitment to truth and reconciliation. To do so, this study answers the following guiding research questions: *How is traditional ecological knowledge represented in selected academic programs?* and *What is the potential contribution of these programs' engagement in knowledge bridging to sustainability solutions?*

This study is based on qualitative analysis of primary, secondary, and tertiary data obtained via one interview, the collection and review of documentation, and the review of published literature about three programs offered in Canadian universities. They are the late Integrative Science program offered at Cape Breton University; Trent University's Indigenous Environmental Science and Studies Program; and the First Nations University of Canada's Indigenous Environmental Science program. Challenges, opportunities, and future perspectives described in the data collected are also highlighted. Together, these inputs are expected to contribute to providing a better understanding of what role(s) these programs can play in advancing sustainability in the context of reconciliation.

3 Literature Review

Since the 1990s IK/TEK have attracted growing international interest (Berkes 2018). This is described as a potential indicative of two things: the need for development of a new ecological ethic by learning from traditional knowledge holders and their wisdom; and "the need for ecological insights from indigenous practices of resource use" (Berkes 2018, p. 20).

Among several factors that can be associated with the increased attention accorded to TEK, the acceptance and usage of indigenous environmental knowledge by scientific experts is closely associated with calls for indigenous and scientific knowledge working together for sustainability solutions (Berkes 2018, Koty 2014, Jung 218, Levac et al. 2018, Leicht et al. 2018, Mastrángelo et al. 2019, Mistry and Berardi 2016, Nakata 2002, Rathwell et al. 2015, Rich 2012, Tengö et al. 2017). Mistry and Berardi (2016), for example, highlight the "growing body of published literature [that] discusses the importance of indigenous knowledge and differing worldviews in ecosystem science and management" (p. 1274). Tengö et al. (2017) argue that "bridging indigenous and local knowledge systems with scientific knowledge systems is vital to enhance knowledge, practice, and ethics to move towards sustainability at multiple scales" (p. 17).

The following sub-sections provide a brief review of literature that deals with frameworks for knowledge bridging in a broad sense, then proceeds to explore IK/TEK in the university context and, finally, presents a summary of the most recent literature on indigenization, decolonization, and the (status of the) reconciliation agenda for Canadian higher education.

3.1 Frameworks for knowledge bridging at a glance

This subsection covers literature on a more general view of how IK/TEK and scientific knowledge can work together and in doing so, play a role in addressing the current social-ecological crisis – also contributing to sustainability solutions. It briefly describes the main similarities and differences pertinent to Western scientific and indigenous knowledges, including the major challenges, opportunities and limitations that result from attempts to bring them together. It then presents frameworks highlighting ways to connect knowledge systems, followed by a brief overview of a typology of settings for bridging knowledge systems. Lastly, it outlines an evidence-based guidance on the bridging of indigenous and local knowledge systems and science to enhance governance for sustainability.

Knowledge and knowledge systems are not static – they change and evolve over time (Berkes 2018, Levac et al. 2018, Nakata 2002, Rathwell et al. 2015, Tengö et al. 2017). Berkes (2018) describes indigenous knowledge and resource management systems as adaptive responses that may involve

"the evolution of similar systems in geographically diverse areas… the elaboration of one basic model of management into a diversity of variations… the co-evolution of people and plants… the major transformation of the landscape from one productive system to another… [and] the synthesis of several traditions, and current commercial pressures, into a new, sustainable, and beautiful system" (p. 272). These adaptive responses have the potential to address emerging resource management problems as well as complex and urgent crises, also helping in attempts to respond to change during turbulent times (Berkes 2018, Mistry and Berardi 2016, Tengö et al. 2017). Three important caveats to keep in mind are that the words 'resource' and 'management' are not even present in many indigenous languages, meaning that traditional knowledge "provides lessons not in resource management but in dealing with human-environment relations" (Berkes 2018, p. 20); that tradition is not necessarily virtuous or adaptive (see Berkes 2018, pp. 16-17); and the acknowledgement that there is no such thing as a single indigenous – or Western – way of knowing (Berkes 2018, Levac et al. 2018).

Nonetheless, several characteristics seem to be common across various indigenous peoples, their cultures, histories and contexts as presented in the literature on indigenous worldviews and knowledges (Berkes 2018, Koty 2014, Levac et al. 2018). Furthermore, the mainstream scientific approach allows for some generalizations (e.g. Levac et al. 2018, Mistry and Berardi 2016).

Instead of thinking about indigenous knowledge as a replacement for Western scientific knowledge, Berkes (2018) argues that the more useful way of engaging with both is through the exploration of their complementarity. Mistry and Berardi (2016) resonate with this understanding when they suggest that in an attempt to solve real world problems, any effort should begin from the indigenous perspective, first engaging with the local communities that are affected the most to then seek relevant scientific input not to validate indigenous knowledge, but rather to "expand the range of options for action" (p. 1275). Tengö et al. (2017) support the complementarity argument, but also go one step further to bring the discussion to a new level: collaboration. They argue for a significant need for effective collaboration across knowledge systems in order to "ensure inclusive and equitable pathways for governing ecosystems within planetary boundaries in the Anthropocene" (Tengö et al. 2017, p. 23). They suggest that to achieve this, equitable engagement with and among knowledge systems is required, thus moving beyond studies into or about the knowledge systems of indigenous and local communities.

Both knowledge systems show similarities and differences, where attempts to bring them together for enhanced sustainable outcomes pose challenges and opportunities. It is also important to

acknowledge the associated limitations that result from these attempts. Berkes (2018) captures the essence of similarities pertinent to indigenous and Western scientific knowledges when he states that "the worlds of the shaman and the scientist are two parallel modes of acquiring knowledge about the universe". Both knowledges are value-laden – just like all knowledges – and include ethical considerations (Mistry and Berardi 2016, Rich 2012), sharing a "fundamental interest in the relationship of humans with the Earth" (Rich 2012, p. 308). Additionally, they are produced by socially situated actors in a context of power relations – i.e. hierarchical, recognizing that there are different levels of knowledge (Berkes 2018, Mistry and Beradi 2016, Tengö et al. 2017). However, when assessing how researchers within and beyond academia are attempting to link indigenous and Western ways of knowing, Levac et al. (2018) raised some critical questions. One of them concerns diversity within indigenous and non-indigenous communities which, according to them, "is not reflected in discussions about linking indigenous and Western ways of knowing" (Levac et al. 2018, p. 15). Berkes (2018), based on Hunn (1993) and additional contributions, provides a list of precautions in conducting ethnobiological research. The often-gendered nature of traditional knowledge, and the unequal distribution of traditional knowledge within a community (thus the need to select the representative of such knowledge carefully) are highlighted.

The main difference between indigenous and Western scientific knowledges concern their underlying ontology with regards to the place of humans in the environment (also being inclusive of the relationships thus established). Indigenous understandings typically place humans as part of the web of life, emphasizing relationships, interdependence, and interconnectedness where humans are not in charge but rather are part of the circle (Berkes 2018, Koty 2014, Rich 2012). Indigenous knowledge is thus reflective of indigenous worldviews, inherently place-based, context-specific, deeply connected to spirituality and often regarding land as having agency, where land provides teachings that ultimately base values and knowledge (Berkes 2018, Koty 2014, Levac et al. 2018, Rich 2012). It emphasizes "a metaphysical, holistic, oral/symbolic, relational, traditional, and intergenerational approach to knowledge" (Levac et al. 2018, p. 4). An important question in indigenous knowledge is "how am I fulfilling my role in this relationship?" (Wilson 2001, p. 177 quoted in Levac et al. 2018, p. 4).

These aspects are at odds with the dominant Western scholarship in which humans are 'above' and 'in charge of' other beings in a planet regarded as an inanimate object, and land is the object of study (Berkes 2018, Levac et al. 2018, Rich 2012). Western science has, to a large extent, been influenced and dominated by the positivist-reductionist paradigm, a philosophical tradition that is seen as anthropocentric, patriarchal, rigorous, focusing on objective reliability and validity (Berkes

2018, Levac et al. 2018, Mistry and Berardi 2016) and whose claim of universal truths "has had profound ramifications for indigenous peoples and their knowledges encapsulated within nation states via processes of colonization" (Hauser et al. 2009, p. 48). Indigenous ways of knowing do not pose knowledge as something to be obtained without considerations on how it is to be used, contrasting with the scientific conceptions of the 'pursuit of knowledge' – i.e. knowledge for knowledge sake (Rich 2012). In short, while the tendency within Western-based sustainability science is "to emphasize issues of management, governance and adaptation, indigenous sciences will likely raise issues of connection, responsibility, and meaning" (Berkes 2018, p. 34). Nevertheless, Levac et al. (2018) highlight the common view shared among numerous scholars and indigenous wisdom keepers that the complementarity of indigenous knowledge and Western scientific knowledge allows for the development of new ways of dealing with existing problems, whereas their contradictions create learning opportunities.

The main challenges that arise from attempts to bring indigenous and Western scientific knowledges together to foster environmental sustainability include potential harm to knowledge integrity, and complex power dynamics issues in a context characterized by a broader tendency of incorporating indigenous communities into the wider 'modern world'. Rathwell et al. (2015) emphasize that it is not easy to maintain the integrity and agency of knowledge holders when attempting to incorporate indigenous knowledge into decision making processes, which leads some scholars to not support indigenous and scientific knowledges working together due to the risk of indigenous knowledge mischaracterization. Mistry and Berardi (2016) point to the "tendency among the scientific community to assimilate local ecological knowledge within Western worldviews of managing nature" (p. 1274). Levac et al. (2018) highlight the serious risks associated with the integration of indigenous and Western knowledges because this implies that "one will be incorporated into, or subsumed by, the other" (p. 4) Tengö et al. (2017) stress that the representation of indigenous and local knowledge systems is often based on 'experts' rather than knowledge holders themselves. These latter authors also emphasize that engaging with indigenous and local knowledge systems takes place in a context of asymmetrical power relations. In this regard, Levac et al (2018) call attention to the history of knowledge marginalization that is characteristic of some knowledges within Western knowledge systems. Though the issue of power asymmetries will be hard to fully resolve, there has been a recent surge in knowledge co-production for problem-solving in areas characterized by critical environmental issues (Berkes 2018).

In the context of environmental change, Rathwell et al. (2015) list moral, political and practical reasons supporting different knowledge systems working together. Mistry and Berardi (2016), for

example, suggest that by adopting their proposed approach (i.e. beginning from the perspective of indigenous knowledge and then seeking relevant scientific knowledge to expand the range of options for action), scientific knowledge would present itself as more acceptable and relevant to those that it seeks to support and, at the same time, would critically promote social justice and establish self-determination as a crucial principle of engagement. The empowerment of indigenous self-governance through regaining control over their own knowledge, as well as the acquisition of expertise in the science forms, is also an important opportunity (Berkes 2018, Hauser et al. 2009, Rich 2012, Tengö et al. 2017). In this respect, Berkes (2018) argues that "the use of indigenous knowledge is political because it threatens to change the power relations between indigenous groups and the dominant society" (p. 278).

Nakata (2002) summarizes the main limitations that arise from attempts of bridging indigenous and scientific knowledges when he states that "the intersections of different knowledges and discourses produce tensions and condition what is possible but do not directly produce certainty of outcomes" (p. 286). These tensions are further explored below with illustrative frameworks for a better understanding of the meeting-point of indigenous and Western scientific knowledges (Levac et al. 2018). But before that, it is important to highlight some of the main associations that can emerge from the parallels between post-positivist and indigenous knowledge, where the latter is characterized by Berkes (2018) as one of the many challenges to the currently threatened dominance of the positivist-reductionist paradigm.

Indigenous knowledge and the post-positivists sciences of social constructivism and complexity share basic beliefs in a consistent way (see Berkes 2018, chapter 12). Complexity and other post-positivist and evolutionary approaches, including systems thinking, are represented in their applied form by Adaptive Management in the area of environmental management, suggested by Berkes (2018) as "a good match for TEK, and a potential bridge between Western and indigenous ways of knowing in the area of ecology and resource management" (Berkes et al. 2000, quoted from Berkes 2018).

The Cultural Interface proposed by Nakata (2002) is described as "a place of constant tension and negotiations" (p. 285) and consists of the intersection where indigenous and Western domains meet. According to the author, if seen as the beginning point, the Cultural Interface acknowledges the inherent non-static characteristic of knowledge systems and fosters the maintenance of the continuity of one knowledge system when having to make use of the other. This way, Nakata (2002) continues, "both must be reflected on and interrogated" (p. 286). The Cultural Interface is among

the 19 models/frameworks that emphasize ways to connect knowledge systems identified by Levac et al. (2018). A summary of these models and frameworks is available on Annex I.

Levac et al. (2018) further indicate that based on a cautious approach, these linking frameworks may facilitate the creation of new ways forward. The 'cautious approach' suggested is inclusive of considerations on power inequalities which, as previously described, are closely associated with (potential harm to) knowledge integrity. This aspect is a fundamental consideration when talking about the bridging of knowledge systems. Rathwell et al. (2015) define bridging knowledge systems as "maintaining the integrity of each knowledge system while creating settings for two-way exchange of understanding for mutual learning" (p. 853). These authors offer a typology of settings for bridging knowledge systems, focusing on the global commons. Described as "a modest offering towards improving knowledge bridging" (p. 872), this typology identifies the epistemological arena, methods and processes, brokerage mechanisms and governance/institutional arrangements as the main categories of settings for knowledge bridging. Rathwell et al. (2015) emphasize that bridging activities requires trust building and resources, and thus take time. They also point to the fact that while bridging activities open to initiatives emerging from within indigenous knowledge communities are crucial, research and policy are often initiated and mediated by Western institutions.

Tengö et al. (2017) stress that enhancing knowledge, practice and ethics to move towards sustainability at multiple scales requires the bridging of indigenous and local knowledge systems. Focusing on international science-policy processes, their approach builds on the previous Multiple Evidence Base[8] to provide guidance for collaborations across knowledge systems. They "present evidence-based guidance on how five tasks – to mobilise, translate, negotiate, synthesise and apply multiple evidence – can bridge indigenous and local knowledge systems and science to enhance governance for sustainability" (p. 18). They further emphasize, and illustrate, that successful collaboration across diverse knowledge systems has in its core the engagement of actors and institutions in equitable and empowering knowledge-sharing processes.

A great need to investigate how the knowledge resulting from joint learning processes that embody critical connections of people and nature may lead to innovative ways of addressing the current

[8] The Multiple Evidence Base (Tengö et al. 2014) is "an approach that addresses the implications of going beyond integrating knowledge and engaging with diverse knowledge systems. This approach recognises the incommensurability of diverse knowledge systems and the often asymmetric power issues arising when connecting different branches of science with locally-based knowledge systems. Complementarity, validation of knowledge within rather than across knowledge system, and joint assessments of knowledge contributions are key aspects of the approach" (Tengö et al. 2017, p. 18).

social-ecological challenges is identified by the Tengö et al. (2017). In a somewhat similar vein, Berkes (2018) suggests that much more has to be done in exploring the ways in which Western and traditional knowledge systems can, or cannot, be used together. The following subsections proposes to look in greater detail at a specific context for knowledge bridging: higher education, with a focus in Canada.

3.2 Indigenous knowledge and the university

This subsection begins with an overview of literature that explores the role of universities in advancing sustainability in the context of Education for Sustainable Development (ESD), leading to literature that explores consideration of IK/TEK perspectives in the university. The focus is on environmental science programs, and issues on IK knowledge representation as well as on its relationship with other curricular elements are briefly outlined. Emphasis on the difference between the 'teaching of IK' *versus* 'teaching **about** IK' is given. The main challenges, opportunities and limitations associated with inclusive programs are highlighted.

Considerations on the efforts to address the social, political and cultural facets of environmental issues have been present in educational agendas worldwide for the past decades, where "the most internationally recognized term for this form of education (used by the United Nations) is Education for Sustainable Development" (Koty 2014, p. 13). At a time of increasing global interest in efforts to tackle sustainability challenges through education, "ESD is placed at the centre of the 2030 Sustainable Development Agenda and has been widely recognized as a key enabler of sustainable development and an integral element of quality education" (Leicht et al. 2018, p. 4). Although a detailed coverage of ESD including its development, competencies, themes, implementation, trends and issues is beyond the scope of this study (refer to Leicht et al. 2018 for more on these), suffice to say that ESD is not meant to be about just teaching sustainable development and adding new content to courses and trainings (Leicht et al. 2018). Rather, schools and universities "should see themselves as experiential places of learning for sustainable development, and should therefore orient all their processes towards principles of sustainability" (Leicht et al. 2018, p. 46).

Stephens et al. (2008) and Waas et al. (2010) explore in greater depth the role of universities in the context of ESD. For these authors, universities can work "as agents for change in advancing more sustainable practices in different cultures and contexts" (Stephens et al. 2008, p. 318). They are also seen as major catalysts to work towards the transition towards a sustainable world (Waas et al. 2010). Providing a historical context for considering higher education as a change agent (Stephens

et al. 2008, pp. 332-333), and echoing the characterization of universities as 'experiential places' discussed above, Stephens et al. (2008) elaborate on the four general categories of perceptions about the potential contribution of higher education to the societal transition towards sustainability. These categories include the capacity of universities to model sustainable practices for society; their potential for teaching skills associated with integration, synthesis, systems-thinking, and complex problem-solving; their potential to conduct real-world problem-based research aiming at addressing the urgent sustainability challenges; and, finally, their potential "to promote and enhance engagement between individuals and institutions both within and outside higher education to resituate universities as transdisciplinary agents, highly integrated with and interwoven into other societal institutions" (Stephens et al. 2008, p.321).

Resonating with these authors, Koty (2014) covers the concept of transdisciplinarity to argue that the combined strengths of multiple disciplines and knowledges – some of them that have been historically suppressed in mainstream education – will be required in order to educate for sustainability. The historical suppression of knowledges is also identified by Rich (2012) when she mentions "the long-standing invisibility and exclusion of knowledges that exist outside of the Western intellectual tradition (p. 308)" and Hall and Tandon (2017), who argue that "what is generally understood as knowledge in the universities of our world represents a very small proportion of the global treasury of knowledge" (p. 7). Hall and Tandon (2017) further explain that knowledge systems present in most universities all around the world derive mainly from the Western canon, and describe how the epistemologies of most peoples of the world are missing – including those of indigenous peoples. They echo Hauser et al. (2009), who assert that "amongst the most debilitating colonial tactics that has persisted is the Eurocentric education system" (p. 45). Hall and Tandon (2017), however, do not only speak about the complicity of contemporary higher education in maintaining unequal knowledge hierarchies, but also show evidence of a possible turning in the university domain.

Hall and Tandon (2017) cover Grosfoguel's (2013) work on the 'Four genocides/epistemicides of the long 16th century' to emphasize that the conquests described were both military and epistemological/ideological. The authors argue that the continued eradication of languages – what they call 'linguicide' – of North America's indigenous peoples, as well as of indigenous peoples elsewhere in the world, illustrate how the patterns established through conquest in the s16th century are "still deeply entrenched in our own minds, and most certainly in our higher education institutions" (p. 12). They also espouse de Sousa Santos (2007) in supporting the claim that "there is no global social justice without global cognitive justice" (63). The authors then briefly discuss

knowledge democracy, described as being about "intentionally linking values of justice, fairness and action to the process of using knowledge" (Hall and Tandon 2017, p. 13). Finally, Hall and Tandon (2017) share "stories of the turning in higher education" (p. 13), describing elements of knowledge democracy discourse and decolonizing practices emerging in universities. In this context, the work of Gregory Cajete – although not included – would fit well.

Having pioneered reconciling indigenous perspectives in sciences with the mainstream academic setting, Gregory Cajete is one of the main leading proponents of indigenous sciences in North America with extensive published work on his understandings (e.g. Cajete 1994, 1999, 2000). He is among the main scholars and educators mentioned by Rich (2012) in her article that illustrates, with a focus in the US. and Canada, why to pursue the linking of indigenous knowledge with teaching and training in environmental science university programming. She urges environmental studies and sciences programs to consider "a commitment to teach not only across academic disciplines, but also across different knowledges or ways of knowing" (p. 308). In this context, she further indicates that indigenous ways of knowing are in tune with the core identity of environmental science programs, where a growing interest in sustainability and resilience topics prompts these programs to engage in practices and activities around issues that are highly relevant to indigenous communities, "topics where these communities bring centuries of tradition to the discussion" (Rich 2012, p. 309). Furthermore, both environmental science programs and indigenous ways of knowing are concerned with "the healing of the relationship of humans with the Earth, the linking of learning with responsibility, and the long-term view necessitated by sustainability goals" (Rich 2012, p. 315).

However, important challenges result from attempts to include IK/TEK perspectives in environmental science university programming. The threats to knowledge integrity, already described, are also present in the academic environment (Hauser et al. 2009, Koty 2014, Levac et al. 2018, Rich 2012). Issues on power dynamics are also highlighted (Hauser et al. 2009, Rich 2012), as well as the uncomfortable relationship of the academia with spirituality (Rich 2012), but the biggest challenges emerge from practical and methodological considerations on whether the classroom setting is appropriate to indigenous ways of knowing. And this lead to the issue involving the teaching of traditional ecological knowledge *versus* teaching about it (Koty 2014, Rich 2012). In this regard, Berkes (pers.comm.) is categorical: "TEK does not lend itself to teaching in a classroom setting. TEK can only be taught by a TEK-holder in the field using apprenticeship style teaching".

But the inclusion of indigenous knowledges in universities is also seen as an important empowering tool for indigenous peoples, especially to improve their participation and success in higher education, contributing to address under-representation – an aspect associated with the fact that conventional education teachings are based on an underlying worldview that dismisses indigenous notions about the world, leading to the alienation of indigenous students (Hauser et al. 2009, Koty 2014, Pidgeon 2016, Rich 2012). Pidgeon (2016) points to the fact that creating meaningful spaces for indigenous peoples within the predominately Euro-Western academic structure poses great challenge, where system-wide and institutional transformations take time. But although indigenous peoples have been experiencing colonization for over 500 years, she asserts that "we do not have another 500 years to wait for change" (Pidgeon 2016, p. 88).She suggests that true indigenization is not a "tokenized checklist response" (p. 77), instead it is "a movement centering indigenous knowledges and ways of being within the academy, in essence transforming institutional initiatives, such as policy, curricular and co-curricular programs, and practices to support indigenous success and empowerment" (p. 77). Resonating with her, Hagan and Huijser (2008) stress that indigenizing cannot be "about simply adding the odd 'indigenous example' to an existing curriculum" (p. 2). Rather, it needs to be what they call a whole-of-institution approach, suggested to be possible 'from below' but that "definitely needs institutional resources and a strong commitment to its objectives 'from the top'" (p. 3). Because it requires culture change, a whole-of-institution approach cannot be seen as a project implying the idea of time limit (which is detrimental to the overall objectives) and should, therefore, be faced as an ongoing commitment (Hagan and Huijser 2008).

Hauser et al. (2009) investigated the Canadian practices in indigenizing tertiary science curricula focusing on two programs: Integrative Science at Cape Breton University; and the then Indigenous Environmental Studies Program at Trent University. Based on measures necessary for ensuring the accountability and appropriateness of indigenized curricula to indigenous communities – i.e. "the embracing of ontological pluralism, the implementation of community-driven programs with inclusive curriculum, and that institutions undertake processes of reflexivity in order to confront limitations that may be imposed upon Other peoples and their ways of knowing within the academy" (p. 49) –, they found that these programs were community-driven, showed an inclusive curriculum and demonstrated the existence of ontological pluralism. However, the requirement of housing universities being reflexive to accommodate indigenous centered programs was met only in part (Hauser et al. 2009). Additional to the tensions emerging from clashes with the ontological foundations of the housing universities – which were described as dominated by the Western scientific knowledge discourse –, they found that conditional and restricted funding imposed

important limitations in terms of, for example, double-staffing (i.e. the hiring of knowledge representatives of both Western and indigenous traditions to teach courses 'side by side').

Rich (2012) highlights that when trying to bring the 'indigenous voice' into the classroom, the following key questions arise: "What is the difference between teaching 'from' and teaching 'about' indigenous ways of knowing, and can both of these approaches play a role? Where does indigenous voice in the classroom come from?" (p. 311). These questions point to important considerations that need to be laid out. Although the ideal would be an indigenous instructor teaching from an indigenous perspective in an indigenous language, this is often not feasible (Koty 2014, Rich 2012). Rich (2012) then suggests that, provided that certain requirements are met (e.g. a respectful atmosphere), the indigenous voice can then come from "indigenous students, guest speakers, students' families, an indigenous advisory committee, a Native Studies department on campus, or outside indigenous communities" (p. 311). But Koty (2014) flags that care must be taken concerning the voice of indigenous students since well-intended but careless approaches, especially from non-indigenous educators, pose the danger of reproducing myths about indigenous peoples if based on the assumption that "indigenous students have innate knowledge about or practice a 'traditional' way of life" (p. 33). As Scully (2012) suggests, the continued teaching and use of faulty indigenous stereotypes "perpetuate profound and dangerous misunderstandings and social injustices towards indigenous peoples" (p. 152).

Additionally, (geographic) distance from the indigenous peoples of interest is challenging in the sense of what constitutes classroom presence of indigenous voice (Rich 2012). A suggested alternative to help the indigenous voice be present is the sharing of results from participatory research projects – particularly those based on collaboration with locally-based indigenous representatives. Moreover, the direct inclusion of students in the research projects is suggested as "an even more effective way of making indigenous voice present in students' learning" (p. 311). Overall, the adequate training of teachers, educators and instructors plays a major role (Koty 2014, Rich 2012, Scully 2012). Acknowledging the need for more research to investigate how indigenous knowledges and perspectives can be made present in the classroom (and leaning towards the teaching about IK/TEK area), Koty (2014) emphasizes certain pedagogical methods to respectfully and appropriately deliver indigenous content. Storytelling and works of art, traditional crafts, song, dance, ceremonies, and rituals are highlighted. These methods are also mentioned by Levac et al. (2018) who, focusing on approaches to research and being inclusive of the concept of

intersectionality[9], list methodologies (principles and methods) that involve learning from multiple knowledge systems. These principles and methodologies are listed on Annex II. The need for community engagement connecting students, educators and member of indigenous communities, especially Elders, is also emphasized (Hauser et al. 2009, Koty 2014). Ultimately, "the embedding of indigenous knowledge [in university curricula], whether or not it should proceed and on what terms, is for indigenous peoples to define themselves" (Hauser et al. 2009, p. 50). Finally, Koty (2014) contends that the classroom is not the ideal context to experience indigenous teachings, but field trips to places of historical and cultural significance to indigenous communities are an alternative to be considered.

The main limitations to including IK/TEK perspectives in (environmental science) programs at the university level include institutional challenges, reluctance of colleagues to consider the validity of other knowledges and ways of knowing, the extent to which a multiple knowledges approach fit well to specific courses (Rich 2012) and the acknowledgement that, as Berkes (2018) states, "the written page will never be an adequate format for the teaching of indigenous knowledge" (p. 42). Additionally, Hagan and Huijser (2008) point out to the dangerous reliance of indigenization practices on 'individual champions'. As they later explain, the risk is that "the whole thing… grind[s] to a halt when individual champions leave" (p. 4).

Nevertheless, bringing indigenous ways of knowing together with environmental science studies can be seen as a valuable enterprise "that promotes critical thinking skills and a more complex perception of human relationships with the Earth" (Rich 2012, p. 315). Rich (2012) and Koty (2014) highlight that results extend beyond the academic context since enhanced critical thinking provides opportunities for the development of solutions for troubling environmental issues as graduates are faced with the challenges of putting their learning into practice. As Pidgeon (2016) suggests, "indigenization of the academy has truly transformed higher education when indigenous students leave the institution more empowered in who they are as indigenous peoples and when non-indigenous peoples have a better understanding of the complexities, richness, and diversity of indigenous peoples, histories, cultures, and lived experiences" (p. 87). Rich (2012) further indicates that the importance attributed to environmental science programs in terms of supporting biodiversity also lends itself to encouraging biocultural diversity of humans. In a historical context

[9] Intersectionality is "a feminist concept originating in the work of African American women, which seeks social justice[also aiming at redressing inequality] by revealing and responding to the ways that people can be both oppressed and privileged when their identities or positions intersect with each other, and with social structures and systems of power. Intersectionality assumes that peoples' experiences are deeply affected by social and political systems" (Levac et al. 2018, p. 1).

of genocide, land dispossession, cultural erasure, and inequities of power (Hauser et al. 2009, Koty 2014, Pidgeon 2016, Rich 2012), "bringing indigenous ways of knowing together with the teaching of ESS [environmental science and studies] does so by extending much-needed hospitality to indigenous peoples and their traditions" (Rich 2012, p. 315).

Pidgeon (2016) elaborates on calls from indigenous scholars to highlight that for indigenization to occur, "it must also be a decolonizing process" (p. 80). Acknowledging the growing calls for the decolonization of universities identified – among others – by Hall and Tandon (2017), the following subsection explores the concept of decolonization which, together with indigenization, are at the core of the reconciliation agenda for Canadian higher education.

3.3 Decolonization and the reconciliation agenda for Canadian higher education

This last subsection briefly presents the implications of decolonization. Together with those of indigenization, they illustrate the main findings and conclusions of recent studies that aimed at looking at these practices in Canadian universities after the release of the Calls to Action by the Truth and Reconciliation Commission of Canada in 2015 (TRC 2015).

According to Scully (2012,), colonization "is a term for the political, economic, social, and cultural oppression of one people over another" (p. 151). Thus, the practices and processes by which European rule spread across the globe over hundreds of years are referred to as colonialism (Scully 2012). Indigenous and non-indigenous peoples in different locations around the world, in an attempt to further the widespread resistance to colonization, have engaged in decolonizing discourse (Scully 2012). Tuck and Yang (2012), in an acute criticism of what they describe as the misuse of the decolonization concept and its associated rhetoric, argue that "decolonization brings about the repatriation of indigenous land and life; it is not a metaphor for other things we want to do to improve our societies" (p. 1). These authors further suggest that as important as the goals of social justice, critical methodologies, or approaches that decenter settler perspectives may be, they not only turn decolonization into a metaphor by adopting decolonizing discourse but they also have objectives that likely are incommensurable with decolonization. They argue that "the metaphorization of decolonization makes possible a set of evasions, or 'settler moves to innocence', that problematically attempt to reconcile settler guilt and complicity" (Tuck and Yang 2012, p. 1).

Jung (2018) draws on Tuck and Yang (2012) when explaining reasons to be careful about the reconciliation endeavor – but for her, their image of decolonization is somewhat utopian, even apocalyptic. She describes that after the release of the Final Report of the Canadian Truth and Reconciliation Commission of Canada, including its 94 Calls to Action (TRC 2015), "many non-

indigenous Canadians, politicians, and educational and cultural institutions have embraced reconciliation" (Jung 2018, p. 252), while the response from indigenous peoples ranges from full engagement to complete resistance. The author then lists six reasons[10] to be cautious about reconciliation, arguing that the development of the practices associated require "first of all, a candid confrontation with the many ways in which it can go wrong" (p. 253). In a discussion covering semantic objections and the potential for revival of the power relations reconciliation is meant to transform, Jung (2008) elaborates on the facet of reconciliation that can be interpreted as a 'move to innocence' as well as on its likely inconsistency with decolonization as put forward by Tuck and Yang[11] (2012). However, Jung (2018) describes how the perspectives and versions of other scholars and activists on decolonization actually give room for reconciliation as a means to promote and sustain a decolonizing approach.

Gaudry and Lorenz (2018) also draw on Tuck and Yang (2012), among others, to describe 'decolonial indigenization' – one of the three meanings for indigenizing that they identified when investigating the different current uses of the term by Canadian universities. They suggest that other versions of indigenization "merely evoke the discourse of transformative change, while using this rhetoric to preserve the *status quo* – the unsustainable and unjust exclusion of indigenous nations from an academy built on top of indigenous homelands" (Gaudry and Lorenz 2018, p. 2). Therefore, the authors argue for decolonial indigenization but also highlight that this more radical and substantive approach "is by and large off the radar of most university administrators" (p. 6). They place decolonial indigenization at one end of a three-level spectrum and, in the middle of this spectrum, they identify 'reconciliation indigenization'.

This 'middle-ground' vision is explained as having originated in the optimism of post-TRC academia, and is characterized by a shift in university governance with the establishment of indigenous advisory and/or reconciliation committees that have set goals for reconciliation indigenization in their universities (e.g. UR 2015). Tamtik and Guenter (2019), for example, conducted a policy analysis of strategic documents of 15 research-intensive Canadian universities in the period of 2011-2018 and found that in spite of some inconsistencies on how different

[10] "Reconciliation may aim to restore a relationship that never existed in the first place, and may limit an indigenous future. Reconciliation may look more like adaptation than transformation. Reconciliation may serve as a government project whose primary aim is to bolster state legitimacy. Reconciliation may reflect the desire, for settler-descendants, for expiation or a 'move to innocence.' Ultimately, reconciliation is about living together, which may be incompatible with more transformative political projects, such as decolonization" (Jung 2018, p. 252).

[11] For Tuck and Yang (2012), "decolonizing the Americas means all land is repatriated and all settlers become landless. It is incommensurable with the distribution of Native land/life as commonwealth" (p. 27).

institutions define 'equity', activities fostering diversity, inclusion and equity "have become a policy priority attached to a variety of institutional action plans and performance reports"(p. 41). Gaudry and Lorenz highlight that, at its core, "reconciliation-based indigenization should center dialogue and collaboration, which ultimately yields space to indigenous intellectual traditions" (p. 5). Resonating with this view, Levac et al. (2018) suggest that reconciliation will require investments in indigenous-specific knowledge systems to the extent that it will require "mutual learning from, between, and across indigenous and Western knowledge systems, without privileging Western knowledge, or appropriating indigenous knowledge" (p. V). And this type of learning, according to them, can be encouraged and supported within universities.

However, Gaudry and Lorenz (2018) further indicate that evidence points to a governance shift that is merely rhetorical, "using the language of partnership and transformation" but failing "to seize on the actual meaning behind the various calls to reconcile" (p. 6). They suggest that true reconciliation indigenization requires universities "to practice what they preach" (p. 6). In this regard, Stein (2020) suggests that "most institutions and individuals have yet to face the full extent of their complicity in colonization" (p. 156). She argues that this is the only way through which the transformation of settler-indigenous relationships will be possible since it would be grounded in the realization of the impossibility of reconciliation. Ultimately, as Jung (2018) asserts, "*although it may not*, reconciliation can work as a project of neocolonial affirmation [emphasis added]" (p. 262).

Finally, at the other end of the spectrum, Gaudry and Lorenz (2018) identify indigenous inclusion which is critically summarized as just "more brown faces in white spaces" (p. 3). This least transformative approach is not suggested as worthless, but perhaps should be viewed "not as an end goal as many universities currently do, but rather as a strategy for building toward systemic indigenization of the Canadian academy" (p. 4). With regards to institutional practice, they indicate that, in general, the Canadian university has "rhetorically adopted an aspirational vision of reconciliation indigenization, but is in fact largely committed to indigenous inclusion" (p. 2). This *status quo*, however, is suggested as being deeply contested particularly by indigenous professors and administrators who often work within and against these policies aiming at the achievement of more transformative visions of indigenization (e.g. Debassige and Brunette-Debassige 2018).

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As previously covered, the conversation on indigenization and decolonization of higher education is both important and highly contentious. In this disputed context, consideration of IK/TEK perspectives in academic programs – and, more specifically, in environmental science programs –

are worth looking at since they not only can influence and contribute to sustainability solutions, but also have a role to play in the Canadian reconciliation agenda. Additionally, at the global level, recent developments in environmental and sustainability scholarship emphasize the increasing interest in indigenous knowledge and knowledge bridging to tackle the current (and worsening) social-ecological crisis. Therefore, there is room for better understanding how environmental science programs that are inclusive of IK/TEK perspectives influence – and potentially contribute to – sustainability solutions. This study aims at providing some small contribution in this direction.

4 Theoretical framework

This study approaches how environmental science programs that are inclusive of considerations of IK/TEK perspectives influence – and potentially contribute to – sustainability solutions from a place-based environmental education perspective as it connects with areas of practical significance for traditional ecological knowledge as common heritage of the humankind, with cross-scale implications.

4.1 Place-based environmental education and glocality

According to van Eijck (2010), by nature, place-based education "deals with local knowledge from the places studied" (p. 190). Sobel (2004), in what is often considered a seminal work on place-based education, defines the concept as

> "the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science and other subjects across the curriculum. Emphasizing hands-on, real-world learning experiences, this approach to education increases academic achievement, helps students develop stronger ties to their community, enhances students' appreciation for the natural world, and creates a heightened commitment to serving as active, contributing citizens. Community vitality and environmental quality are improved through the active engagement of local citizens, community organizations, and environmental resources in the life of the school" (Sobel 2004, p. 6)

Place-based education, therefore, is a teaching-learning process that fosters the building of connections with the local environments by exploring and learning from them (van Eijck 2010). van Eijck (2010) also describes the outcomes of place-based education as beneficial to communities at large, where this approach can also been considered a form of environmental education that resulted from attempts to bring youth closer to their natural environment as well as to the problems affecting it. This 'ecological place-based education' is thus inclusive of lessons on how to act "responsibly and ethically within and toward this environment" (van Eijck 2010, p. 188), which the author describes as an introduction to education for ecojustice.

Koty (2014) suggests that a variety of scholars and educators identify place-based education approaches as well suited to environments impacted by colonialism, with the potential to contribute to the efforts towards the decolonization of mainstream education. For example, Scully (2012) proposes that "a complex and rich understanding of place can change the view from where one is standing" (p. 152) .Most of these authors, Koty (2014) continues, draw on David Gruenewald's (2003) work. He "has enormously influenced the field of place-based education by giving a conceptual framework for a critical pedagogy of place" (Koty 2014, p. 21).

Grounded in "socio-ecological traditions that interrogate the intersection between cultures and ecosystems" (Gruenewald 2003, p. 10), a critical pedagogy of place encourages students to improve the social and environmental conditions of places while building meaningful relationships. Its twin objectives, reinhabitation and decolonization, involve " learning to live well socially and ecologically in places that have been disrupted" and "learning to recognize disruption and injury and to address their causes", respectively (Gruenewald 2003, p. 9). Scully (2012) adds reconciliation to the goals of decolonization and reinhabitation. For her, the recognition from indigenous and non-indigenous peoples that they share land in the present represents reconciliation.

Koty (2014) highlights that while some scholars and educators have worked towards the goal of grounding Gruenewald's critical pedagogy of place in indigenous knowledges and perspectives (e.g. Scully 2012, Sutherland and Swayze 2012), others are more skeptical about the appropriateness of a critical pedagogy of place applied to indigenous contexts. For example, some scholars claim that it still carries too many Western and Eurocentric assumptions and conceptualizations (e.g. Bowers 2008, Calderon 2014, Tuck and Yang 2012). Another contentious subject concerns the complexity behind 'placelessness' and its inner *versus* outer drivers leading to territorial displacement, as well as the danger of romanticized notions of indigenous peoples (Nespor 2008).

van Eijck (2010) not only explains the inherent tensions of the focus of ecological place-based education being frequently the natural scientific aspects of place[12], but also elaborates on 'aggravating factors' when place-based education merges with critical pedagogy. In this context, place-based education involves social constructs where place is thus defined by the perspectives people attribute to it, and "there are as many natural worlds and senses of place as there are different people" (van Eijck 2010, p. 189).

'Place' derives from the ancient Greek work *plateia*, which "is not some position, not an empty space, but an area that becomes significant because of the events, meetings, feasts that 'take place' in the place, which thereby comes into existence as place by virtue of the event" (van Eijck 2010, p. 189). And given the continuously unfolding nature of place as it is lived, the discipline of place-based education is characterized by a "challenging process of scholarly development" (van Eijck 2010, p. 190). Nevertheless, Koty (2014) asserts that "the concept of place in education can be a

[12] In short, this tensios refer to the insulation of place-based education from social conflicts as the result, at least in part, of place-based education acting "as a countermovement against those forms of science education in which students often lose their sense of place by focusing on global or abstract issues" (van Eijck 2010, p. 188).

starting point to analyze Canada's history of colonization and contemporary relations between indigenous peoples and settlers" (p. 4).

A critical pedagogy of place is grounded in the local, but students also investigate how place is affected by global processes. As such, they gain an understanding of the interface involving the local, the regional, and the global (Koty 2014). In this local *versus* global conversation, the concept of 'glocality[13]' is worth looking at. In the context of environmental issues, there is no agreement in terms of when and who first used the motto 'think global, act local' (Visser 2011). Its most visible and practical expression can be associated with the launch of the Local Agenda 21 in 1992 during the Rio Earth Summit. The Agenda was a program of action for local application of the global principles of sustainable development (Visser 2011). Echoing aspects of the 'think global, act local', and "in contrast to environmental education approaches that focus primarily on the global issues concerning sustainable development, place-based programs begin by encouraging students to build a 'sense of place'" (Koty 2014, p. 20). 'Sense of place' is an inherent characteristic of traditional ecological knowledge systems.

Berkes (2018) explains that in spite of the local generation that is characteristic of traditional ecological knowledge, not only there is evidence of the existence of "similar ecological adaptations in comparable areas" but also of traditional systems showing "functional equivalents in quite different cultural and geographic settings" (Berkes 2018, p. 70). The study of traditional ecological knowledge – as well as of sustainability solutions associated with it – goes, therefore, beyond local significance (Berkes 2018).

4.2 Traditional ecological knowledge as common heritage of the humankind: areas of practical significance

Berkes (2018) highlights that "the need for indigenous groups to control their knowledge has to be balanced against the need to share their insights as part of the common heritage of the humankind" (p. 42). The author proposes a list containing 'eight areas of practical significance for traditional ecological knowledge as common heritage of the humankind'. These areas, Berkes continues, are not meant to be exclusive categories but instead, they meld into each other. Additionally, they only deal with aspects of ecology and resource use. The areas are 'Biological information and ecological

[13] Visser (2011) explains that the term is said to have its origins in the Japanese word *dochakuka*, which translates to 'global localization'. Initially associated with farming activities and subsequently developing into a marketing strategy, the English word 'glocal' was first coined by Akio Morita (the founder of Sony Corporation) and further popularized in the West by sociologists in the 1990s. The underlying concept of 'think global, act local', in turn, has more varied origins and in an abstract sense, is captured by the German philosopher Goethe when he proposes: "If (we) would seek comfort in the whole, (we) must learn to discover the whole in the smallest part" (Visser 2011, p. 1).

insights', 'Resource management', 'Conservation of protected areas', 'Biodiversity conservation', 'Environmental monitoring and assessment', 'Development', 'Dealing with disasters and modern crises', and, finally, 'Environmental ethics' (Berkes 2018). Table 4.1 describes each of these areas in greater detail.

Table 4-1*. Eight areas of practical significance for traditional ecological knowledge as common heritage of the humankind*

Areas of practical significance for traditional knowledge as common heritage of the humankind	
Areas	**Sustainability solutions**
Biological information and ecological insights	New scientific knowledge derived from perceptive investigations of traditional knowledge with respect to species identifications and crop varieties, natural history, behavior, life cycles, and species interrelationships (e.g. 'three-sisters' agriculture and the use of local knowledge to fill data gaps)
	Insights on ecosystem dynamics (e.g. applications of traditional knowledge in ecological restoration)
Resource management	Prediction of potential resource collapse (e.g. information from resource users like fishers combined with scientific data contributing to knowledge on the resource)
	Alternative models for resource management (e.g. models that involve the use of local knowledge to substitute or complement scientific knowledge)
	Traditional ecological knowledge as a potential tool for Adaptive Management (considering the use of TEK in an experimental way to learn from management interventions, with subsequent policy changes)
Conservation of protected areas	Co-management, with likely effectiveness of the use of traditional knowledge for conservation.
	Environmental management applications based on traditional knowledge (e.g. water buffalo grazing in Keoladeo National Park in India)
	Areas traditionally conserved by local people as sustainable use areas (e.g. sacred natural sites)
Biodiversity conservation (stewardship of biodiversity)	Special interest to traditional knowledge and resource management systems which allow less intensive use and greater biodiversity (e.g. succession management, rotational use, and the creation of patchiness by the use of fire and other kinds of disturbance)
Environmental monitoring and assessment	Time-tested, in-depth local knowledge of people – who are dependent on local resources for their livelihood – can be useful in monitoring local ecosystems and environmental change, in environmental assessments, and in evaluating the environmental impacts of proposed developments. This is so especially when developments push through before there is time for the proper completion of scientific studies. Indigenous control of traditional land-use information, however, is fundamental to maintaining the proprietary nature of such information and the way in which it is put to use in environmental assessment

Development	Use of traditional ecological knowledge benefitting development by providing more realistic evaluations of local needs, environmental constraints, and natural resource production systems
	'People's science' supporting culturally sustainable development (e.g. herding yaks in Pamir pastures)
	Traditional knowledge as a major tool among practitioners who hold that development must be woven around people (e.g. economic development based on local resources with increasing interest in Indigenous knowledge and stewardship of medicinal plants, non-timber forest products, and agroforestry)
	People-oriented development endorsing and supporting sophisticated but threatened livelihood strategies
Dealing with disasters and modern crises (extreme weather events)	Abilities, associated with traditional knowledge, in identifying early warning signs (e.g. some Asian coastal communities in the 2004 tsunami)
	Social memory and resulting social system organization to withstand disturbance (e.g. strong social memory of hurricanes in some of the Pacific islands, with people having a portfolio of responses. For instance, chiefs directing labor to planting instead of fishing)
	Some Indigenous and traditional groups have concepts of land that can help in post-disaster recovery (e.g. the Australian Indigenous notion of country offering an effective and appropriate way of framing the social dimensions of post-disaster relief and recovery)
	Some Indigenous groups have predictive abilities regarding natural disasters and weather phenomena (e.g. Andean ethnoclimatology: Indigenous potato farmers observe the Pleiades to predict rainfall, where the characteristics of the Pleiades have been associated with the severity of the El Niño conditions by scientists investigating the potential relationship. 'Reading the Pleiades' suggested as a forecast that is as good or better than computer-modeling predictions)
Environmental ethics	Notion that everything is interconnected, and conceptualization of humans as part of the natural environment (e.g. various attempts to incorporate ethical values from traditional systems into contemporary society)

Source: compilation by Berkes (2018, pp. 42-55) based on other sources provided in the referenced publication, further elaborated by the author.

As noted by Berkes (2018), many of the points introduced in his proposed list concern people both at the local as the global levels, with "tangible and practical reasons why traditional ecological knowledge is so important… apart from the ethical imperative of conserving cultural diversity" (p. 42).

The 'eight areas of practical significance for traditional ecological knowledge as common heritage of the humankind' were applied to analyzing knowledge bridging in the university context such that activities and practices (e.g. events, research projects, course proposals) were assessed and their fit to one or more areas was established based on their characteristics described in the data sources analyzed. These areas thus relate to the bridging approach present in the programs in the form of evaluation criteria. They were also associated with the 'think global, act local' principle since a prevalent aspect of these areas is that they anchor knowledge in a particular 'sense of place', while the issues they relate to are often global, thus related to the cross-scale implications of glocality. Notions on glocality echo some critical aspects that place-based environmental education entails.

Figure 4.1 depicts in a simple diagram this theoretical framework, used to analyze data derived from the interview, documentation and literature related to three selected university programs in order to provide an overview of how the knowledge and training they offer reflect in sustainability solutions in the Canadian context of reconciliation.

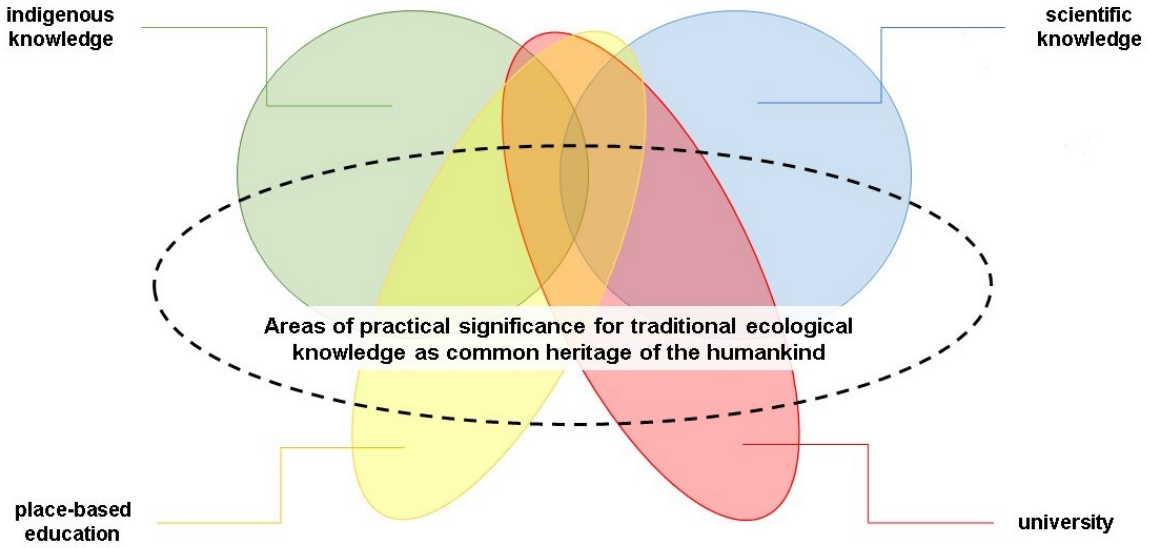

Figure 4-1. *Theoretical framework at a glance.*

This simple diagram illustrates the theoretical framework employed in this study. The circles represent knowledge domains. The green one depicts indigenous knowledge and the blue one, Western-scientific knowledge. The university domain, in red, largely lies on Western knowledge. Place-based educational approaches (yellow) embrace, to a certain extent, both indigenous and Western knowledges and can take place in an academic context. The areas of practical significance for traditional ecological knowledge as common heritage of the humankind (dotted), as employed in this study, encompass elements of all the previous domains. These shapes are **merely illustrative** and are not meant to accurately depict the dimension, level, and/or degree of the domains represented; nor intensity of all overlaps/interactions – or lack of them.

Source: elaborated by the author

5 Methodology

The following subsections describe the steps taken in terms of data collection, data analysis and, finally, present methodological and ethical considerations pertinent to this study. Before proceeding to the data collection protocol employed, it is important to lay out some considerations regarding the general study approach.

The two research questions[14] originally proposed had two major aims. The first aim was to provide an up-to-date assessment of the status of currently offered 'Indigenous Environmental Science programs' in Canada, and whose core principles include the representation of IK/TEK in curricula. This assessment was to be based on literature review on the indigenization of Canadian higher education (building on the literature review performed for the development of the research proposal), as well as data collected via semi-structured interviews with program coordinators and faculty supported by program documentation available online. The resulting primary, secondary and tertiary data obtained would be qualitatively analyzed. Analysis would draw on old and new institutional theory perspectives, following Frølich et al. (2013), to investigate internal and external factors that influence the institutionalization of IK/TEK in the indigenous environmental science programs of interest. Additionally, it would take into account the "measures… necessary for ensuring the accountability and appropriateness of indigenized curricula to indigenous communities" proposed by Hauser et al. (2009), being inclusive of the seven principles found at the bases of indigenous-Western knowledge linking frameworks, and intersectionality, proposed by Levac et al. (2018, Annex II).

The second aim was to shed light on the contribution of the knowledge gained through such programs to sustainability solutions based on answers provided by alumni and graduating students via an online anonymous survey (template on Annex III), and semi-structured interviews with other IK/TEK practitioners. The resulting primary data would be qualitatively analyzed in light of Berkes' eight areas of practical significance for traditional ecological knowledge as common heritage of the humankind (2018, pp. 42-55), including considerations on cross-scale implications.

However, several factors led the study approach to shift to its current format. Consultations held with academic IK/TEK authorities raised concerns on research ambitions, as well as the validity of the potential results and conclusions associated with the first research aim since the proposed

[14] Research question 1 was "What is the status of Indigenous environmental science programs at selected Canadian universities?". Research question 2 was "How IK/TEK in the academic context may contribute to solutions to the current social-ecological crisis?"

'status evaluation' was deemed "not an easy task" (Berkes pers.comm.). One issue was that there are no agreed upon frameworks for assessing knowledge bridging, and thus conclusions drawn (based on principles common to some of the linking frameworks described in the literature) would likely be prone to controversy. Additionally, implications on the interpretation of 'teaching of IK' *versus* 'teaching **abou**t IK' in a mainstream academic setting (as briefly covered in subsection 3.2 above) were named as another area of concern. On top of that, conducting the intended interviews and the attempt to access the alumni population of a selected program via institutional communication were hindered by the outbreak of the COVID-19 pandemic through March – May 2020, an aggravating factor since this period coincides with the end of the Winter term. These latter aspects considerably impacted the possibilities of accomplishing both research aims.

Therefore, the research plan was reviewed, updated, and adapted, reflecting the limitations related to the availability of time, resources, tools, and capacities as the result of the COVID-19 pandemic. Data collection and data analysis protocols employed are described below, and the main component of the research approach undertaken consists of literature review.

5.1 Data collection

Based on literature accounts of environmental science programs inclusive of IK/TEK perspectives offered by Canadian universities (Hauser et al. 2009, Koty 2014, Rich 2012), and upon successful communication with Dr. Gendron – Professor of Biology and department head of the Department of Indigenous Science, the Environment and Economic Development (DISEED) at the First Nations University of Canada (FNUniv), located in Regina, Saskatchewan, CA) –, the first steps towards data collection took place. Primary, secondary, and tertiary data were collected to answer the proposed research questions.

Primary data was obtained via one semi-structured online interview – and subsequent follow-up via email for clarification – with Dr. Gendron. An illustrative interview guide containing the leading questions proposed during the interview is provided on Annex IV. Secondary and tertiary data were obtained from documentation available online (e.g. webpages, reports, peer-reviewed articles, book chapters, and other miscellaneous resources). Documentation associated with the academic programs included information from one program no-longer offered, and two existing programs. The former is Cape Breton University's Integrative Science (IS) program, which functioned from 1999 to 2007 (Bartlett 2012, Bartlett et al. 2012, Integrative Science 2020). The latter two are Trent University's Indigenous Environmental Science and Studies (IESS) program and the Indigenous Environmental Science (IES) program offered at FNUniv.

Various miscellaneous files were retrieved from the IS program website (http://www.integrativescience.ca/), including presentations and summaries of activities as well as literature – i.e. articles and book chapters (Bartlett 2011, Bartlett 2012, Bartlett et al. 2012, Bartlett et al. 2015, Hatcher 2012, Hatcher and Bartlett 2010, Hatcher et al. 2009a, Hatcher et al. 2009b, Iwama et al. 2009, and Marshall et al. 2010). Concerning the IESS and IES programs, six reports were collected (IESS 2016, 2017, 2018, 2019, FNUniv 2016, 2017) from their websites (https://www.trentu.ca/iess/ and http://fnuniv.ca/a-programs, respectively). With regards to literature specific to the IESS and IES programs, one article (Kapyrka and Dockstator 2012) and one book chapter (Evering and Longboat 2013) were reviewed for the former and, for the latter, one article associated with activities that take place in the context of the program was reviewed (Ferreira et al. 2014). Another source of information about the IS and IESS programs was their profiles provided in Rich (2011)

5.2 Data analysis

Data was analyzed qualitatively, and programs were analyzed separately. All data collected was reviewed and the main aspects associated with place-based environmental education – as well as cross-scale implications – were synthesized. For all the three programs, webpages and reports (and for the IES program, content from the interview plus follow-up with Dr. Gendron) were reviewed to identify practices and/or activities that could be relevant to answer the proposed research questions – i.e. accounts of teaching experiences/objectives and/or research within the scope of the program evidencing consideration of IK/TEK perspective likely to influence sustainability solutions.

This information was first organized in an Excel sheet – each of these practices/activities dealt with as 'items' – based on their main nature in terms of teaching and/or research and/or outreach. This initial organization also included a brief summary of each item. These summaries were then classified according to themes that were defined in an iterative way: at first in association with the proposed areas and solutions present in Berkes' (2018) framework, and subsequently attributed its own theme in case none of the areas nor solutions were deemed a good fit.

Finally, a summary of challenges, opportunities and future perspectives (drawing upon the IS experience, and considering the current situation of the IES and IESS) associated with both knowledge representation and the contribution of consideration of IK/TEK perspectives to sustainability solutions was pursued. These aspects were mainly considered in relation to the

literature relevant to the programs – and, for the IES program specifically, in relation to the interview conducted with Dr. Gendron.

5.3 Methodological and ethical considerations

General considerations include clarification on what the results, discussion and conclusions are meant to elucidate. The findings as presented in this study by no means imply a judgement of merit or value indicating which program is 'better'. Rather, results and discussion elaborate on findings from each program in an illustrative manner, taking into consideration information that was possible to assess via the protocols for data collection and analysis adopted.

Important limitations also need to be delineated – especially lack of primary data. Results, discussion and conclusions are presented here acknowledging the likelihood of individual courses in various universities and colleges – as well as other programs – including consideration of IK/TEK perspectives that potentially influence and contribute to sustainability solutions. Therefore, an examination of the selected environmental science programs alone does not mean that the subsequent results and conclusions refer solely to the programs that can influence sustainability solutions, or the only solutions that can be influenced by consideration of IK/TEK perspectives at the post-secondary level. Even within the programs of interest there are relevant practices, activities, research, and projects that were likely missed given the data collection and analysis protocols. Triangulation combining, for example, the review of documentation and literature, interviews, and participant observation would be desired to maximize the quantity and quality of data collected. Although initially planned, triangulation was not possible for this study as a result of the limitations imposed by the COVID-19 outbreak.

In terms of ethical implications, anonymity in the interview was handled in accordance with the desire of the interviewee to be identified. The recording and/or note-taking of the interview was conditional to the interviewee's approval. She was informed that the main purpose of the research was the production of a masters' thesis that will be made available to the general public through CEU's library (https://library.ceu.edu/ceu-library/electronic-theses-and-dissertations-etds/). Concerning confidentiality, virtual files from the interview were stored in the author's personal cloud as well as in an external drive with no mentions of data source/personal information in the description of these files. Written/printed materials from the interview were only handled by the

author and stored in the author's personal archives. Furthermore, the thesis proposal associated with this study was subject to CEU's ethical policy and review on research[15].

Upon request, the IES subsection of the Results section was reviewed by the interviewee prior to thesis submission. Following the completion of this research project (i.e. submission of the final version to the CEU library and thesis defense), a copy of the final thesis report (pdf file) and summary of findings (i.e. a policy brief-like document in pdf format) will be sent to the interviewee via email. This latter document will also be sent to all the academics and practitioners consulted who despite not fully engaging in data collection for various reasons, provided support and insights to the research approach undertaken.

[15] CEU's ethical policy and review on research available at https://documents.ceu.edu/documents/p-1012-1v1805.

6 Results

6.1 Selected environmental science programs: profiles

6.1.1 Integrative Science Program at Cape Breton University

Integrative Science was "a globally unique undergraduate science program created in the mid-1990s at Cape Breton University (CBU) in Sydney, Nova Scotia" (Bartlett et al. 2015). It considered science to be "dynamic, pattern-based knowledge shared through stories about our interactions with and within nature" (Bartlett 2011, p. 179). This view, the author continues, acknowledges that distinct cultures may frame and share their stories in different ways by using different combinations of the multiple intelligences of humans[16] (for more information, see Hatcher et al. 2009a). The program originated from the interest of representatives of the Mi'kmaw First Nation community of Eskasoni[17] in university-level action that would help reverse the very low number of Mi'kmaw students enrolled and/or who successfully completed CBU's science-related programs; and to address, in part, the failure within the scientific community to acknowledge indigenous knowledge in science-related curricula (Bartlett 2011, Bartlett et al. 2012, Bartlett et al. 2015). Integrative Science was approved by CBU's Board of Governors as a concentration within the four-year degree BSc Community Studies in 1999 (Bartlett 2011, Bartlett et al. 2012). For several reasons that are further detailed later, the program and the degree ceased to function in the late 2000s (Bartlett 2012, Bartlett et al. 2012).

Integrative Science was guided by 'Two-Eyed Seeing'. The concept – the definition of which is present in most, if not all, documentation and literature associated with the program – was brought forward by the Mi'kmaq Elder Albert Marshall of Eskasoni First Nation, who was an inmate of the Canadian residential school system. Hatcher et al. (2009b) describe how the experience profoundly affected him, which "led him on a lifelong quest to connect with and understand both the culture he was removed from and the culture he was forced into and to help these cultures find ways to live in mutual respect of each other's strengths and ways" (pp. 145-146).

[16] Harvard University psychologist Howard Gardner recognized nine intelligences, of which more holistic sciences – such as indigenous peoples' sciences – tend to draw upon the interpersonal, intrapersonal, musical, body-kinesthetic, spatial, naturalistic, and/or spiritual intelligences.Western sciences, in turn, privilege logical-mathematical and linguistic intelligences (Bartlett 2011)

[17]The Mi'kmaw people are the original people of an area that extends from northeast New England to the Canadian Maritime provinces (Rich 2011). Bartlett et al. (2015) explains that in the context of the IS program, they use Mi'kmaw to denote the adjective and Mi'kmaq, the noun. According to the Government of Nova Scotia (2020), Mi'kmaw is singular, Mi'kmaq is plural, and Mi'kma'ki refers to the territory. Mi'kam'ki is thus the the traditional territory of the Mi'kmaw people encompassing Nova Scotia, New Brunswick, Prince Edward Island, the Gaspé region of Québec, Newfoundland, and parts of northwestern Maine (Bartlett 2011).

'Two-Eyed Seeing' first came into use in 2004 in the context of the IS program (Bartlett et al. 2012, Bartlett et al. 2015). It "encourages that we learn to see from one eye with the best in the indigenous ways of knowing and from the other eye with the best in the Western (or mainstream) ways of knowing and, moreover, that we learn to use both these eyes together, for the benefit of all" (Bartlett et al. 2015, p. 283). Elder Albert Marshall and his late wife, Elder Murdena Marshall – as well as the biologist Dr. Cheryl Bartlett[18] – worked closely together for over 20 years, time during which they underwent a journey "to weave indigenous and mainstream knowledges within science curricula and related research projects" (Bartlett et al. 2012, p. 332). Integrative Science is framed as a 'co-learning[19] journey' whose goals have always been "to encourage improved cross- and transcultural understanding, participation, and innovation in science in its various arenas of relevancy" (Bartlett et al. 2015, p. 284).

Rich (2011) explains that Dr. Bartlett distinguished between co-learning and 'Two-Eyed Seeing' in such a way that co-learning "is a way of teaching that emphasizes differences and common ground between ways of knowing. Two-Eyed Seeing, however, emphasizes the strengths of each way of knowing" (Rich 2011, p. 70). According to Hatcher (2012, p. 355), "using the guiding principle of Two-Eyed Seeing, education melds the indigenous sciences sense of the whole with the Western sciences sense of the parts". The need to learn how to weave back and forth between knowledges is indicated by Elder Albert Marshall (Bartlett et al. 2012). This need is because for each situation, "it may be that one has more applicable strengths than the other" (p. 33 5) but this can easily switch when circumstances change (Bartlett et al. 2012).

Bartlett et al. (2015) specify how 'integrative' is **not** being used in Integrative Science. The authors acknowledge the Canadian history of injustice towards indigenous peoples and express their desire in not further contributing to misunderstandings. 'Integrative', they continue, "is not used in the sense of two knowledge systems merged into one" (p. 284). They emphasize that not only merging knowledges is not their intent, but it would also "hold open the door to knowledge domination and assimilation" (p. 284), what they characterize as a new form of hegemony. 'Integrative' is described as not being used in the sense of taking bits and pieces from indigenous knowledges and ways of knowing to append them to Western knowledges and approaches either (Bartlett et al.

[18] Former Director of the late Institute for Integrative Science & Health at Cape Breton University and Tier I Canada Research Chair in Integrative Science, awarded in 2002 and renewed in 2009. For more on Dr. Bartlett's profile, refer to http://www.integrativescience.ca/People/Director/

[19] Co-learning defined as a process that "involves learning from each other, learning together, learning our commonalities and differences, and learning to see how to weave back and forth between our cultures' actions, values, and knowledges as circumstances require" (Bartlett et al. 2015, pp. 285-286).

2015). They highlight that the suffix '-ive' in 'integrative' indicates the ongoing nature of a co-learning journey – as opposed to what 'Integrated Science' would denote – and their mindful as well as spiritual intent "to talk and walk together in mutual respect to develop a living knowledge of collaboration for the twenty-first century" (Bartlett et al. 2015, p. 309).

The visual used to explain 'Two-Eyed Seeing' depicts two eyes positioned behind two connected pieces of a jig-saw puzzle (Figure 6.1). This, Bartlett et al. (2012) explain, emphasizes that Mi'kmaw understandings are one among the multitude of indigenous views. It also emphasizes that all the world's cultures, including mainstream/Western science, have understandings to contribute to addressing local to global challenges. Therefore, "one might wish to talk about Four-Eyed Seeing, or Ten-Eyed Seeing, etc" (Bartlett et al. 2012, p. 336, Bartlett et al. 2015, p. 297).

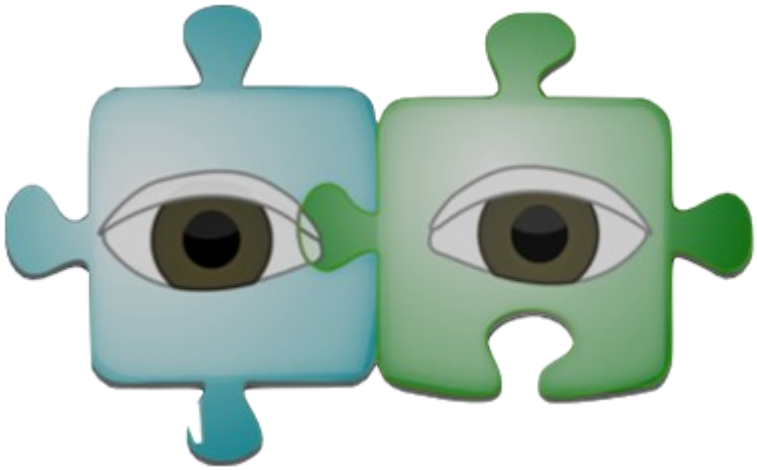

Figure 6-1. *Two-Eyed Seeing.*

The visual used to explain 'Two-Eyed Seeing' depicts two eyes positioned behind two connected pieces of a jig-saw puzzle. This emphasizes that Mi'kmaw understandings are one among the multitude of indigenous views, and that all the world's cultures – including mainstream/Western science – have understandings to contribute to addressing local to global challenges (Bartlett et al. 2012, Bartlett et al. 2015).

Source: Integrative Science (http://www.integrativescience.ca/Principles/TwoEyedSeeing/)

6.1.2 Indigenous Environmental Science and Studies Program at Trent University

Trent University, a liberal arts and science-oriented institution in Peterborough, Ontario, offers North America's first Indigenous Environmental Science and Studies program. The program started as a few introductory courses then turned into an emphasis that students could add to other degrees in 1999, evolving to a degree specialization in 2002. In 2009, it became a degree-granting program offering a two-year Diploma or a four-year BA or BSc (Evering and Longboat 2013, IESS 2019, Kapyrka and Dockstator 2012, Rich 2011).

The program brings together principles of both indigenous knowledges and Western science through a variety of courses offered in the Indigenous Studies Program and through the Trent School of the Environment – as well as unique courses within the program. The focus is on indigenous knowledges from the larger context of indigenous peoples living in place whether in local or in international areas. These courses are directed towards students interested in bringing together indigenous and Western science to address complex environmental issues (Evering and Longboat 2013, IESS 2016, 2017, 2018, 2019, Kapyrka and Dockstator 2012, Rich 2011). Latest student demographics suggest that 83% of students enrolled in the IESS program identify as non-indigenous and 17% as indigenous (IESS 2018).

The IESS program was developed by Dr. Roronhiake:wen Dan Longboat – a Turtle Clan Kanyen'kehá:ka (Mohawk Nation) from the Grand River Territory at Ohsweken – through his Masters' studies at York University. He is the program's founding director and an Associate Professor at Trent University. Besides having a Ph.D. in environmental studies, he is also recognized for his traditional Haudenosaunee (Six Nations Confederacy) knowledge (Evering and Longboat 2013, IESS 2019, Rich 2011).

Kapyrka and Dockstator (2012) characterize Trent's IESS program as grounded in a 'two-worlds' approach to environmental education. This approach, the authors suggest, "acknowledges the differences between the knowledge systems of both indigenous and Western perspectives – it upholds tenets of both methods of learning" (p. 106). Key features of this approach include no intent to merge knowledge systems together, nor to paste bits of indigenous knowledge onto Western curricula. Instead, it engages in a learning philosophy based in equitable inclusion aimed at avoiding knowledge domination and assimilation (Kapyrka and Dockstator 2012).

The learning experience provided by the IESS program is expected to change students in such a way that knowledge, according to Dr. Longboat, "will move from being 'head' knowledge to being 'heart' knowledge" (Rich 2011, p. 100). IESS students come from different backgrounds and are asked to relate the program's teachings to their own understandings and experiences. He stresses that the hope is for students' learning to translate into active behavior. Among the main principles of the program, and to insure human survival, Dr. Longboat indicates that "information must move from being a 'commodity' (part of the 'information economy') to being knowledge for the benefit, enhancement and sustaining of all, and from there, to becoming wisdom" (Rich 2011, p. 100).

The program's core courses have not changed much since 2016 (the earliest report available on the program's website) and present students every year with a great variety of guest speakers – a lot of

them representatives of indigenous communities (IESS 2016, 2017, 2018, 2019). For each year of the four-year degree, the courses show a specific focus, namely: Knowledge and Knowledge Systems in the first year; Cultural/Science course focus in the second year; Issues and Knowledge Interaction in the third year; and, finally, Research and Realities in the fourth year (IESS 2017, 2018, 2019). IESS (2019) provides an up-to-date overview of the core courses offered.

6.1.3 Indigenous Environmental Science Program at the First Nations University of Canada

Starting as a degree in 2016, the BSc in Indigenous Environmental Science is a joint program offered through the First Nations University of Canada and the University of Regina's Faculty of Science (FNUniv 2020, Gendron pers.comm., UR 2020c, UR 2020d). With the goal of offering "a Science degree where students would learn not only about science but also about indigenous knowledge, environmental economics and community development", the program was proposed by the Science unit at the FNUniv (Gendron pers.comm.).

Dr. Gendron (pers.comm.) highlighted that although open to both indigenous and non-indigenous students, the IES program was especially designed to attract and retain indigenous students who often associate science with 'bad' previous experiences (e.g. hard subjects in high school). Science, then, is presented in such a way that these students find themselves interested, being able to relate to the content that is taught by instructors and Elders working together (Gendron pers.comm.). She explained that scientific training is thus introduced as something that indigenous students can enjoy and consider as valid for their future paths. Overall, the program is expected to provide all students with tools to work and become experts in multi-faceted disciplines in areas such as environmental assessment, environmental resource management, mining, land development, natural resource exploration, and health impact (UR 2020a, 2020c). No student had yet graduated from the program as of April 2020 (Gendron pers.comm.).

The guiding principles of the IES program include a solid core of both science and indigenous knowledges, complemented by courses that focus on environmental and ecological topics that are inclusive of indigenous worldviews (FNUniv 2020, Gendron pers.comm., UR 2020d). Courses cover not only science foundations (e.g. Biology, Chemistry, Mathematics, and Physics) but also include topics such as Indigenous Environmental Science, Indigenous Studies, Environmental Studies, Economics and Law (FNUniv 2020, UR 2020d). The program is subdivided into five 'sections'. They are Basics and Breadth Courses, Environmental Courses, Indigenous Courses, Economics and Law Courses, and Approved Electives (UR 2020d). An up-to-date list of courses is available on the University of Regina 2020-2021 Undergraduate Calendar (UR 2020a, pp. 255-256). The most recent information about the courses can be viewed on the University of Regina

2020-2021 Undergraduate Course Catalogue (UR 2020b). The degree allows flexibility through the offering of some online courses (FNUniv 2020, UR 2020d).

Elders' engagement in the program's activities are an important component of the degree. Dr. Gendron (pers.comm.) emphasized that courses are designed under a 'knowledge-bridging approach', where Elders bring traditional knowledges, views and practices to the courses while faculty like herself, who are non-indigenous, explore more of the Western-scientific aspects of a given topic or subject. Faculty were associated with the role of 'facilitators of bridge-making'. Elders, she explained, are representatives of different communities. Some of them are part of the FNUniv Elders' Council[20], while others become involved in the courses for various reasons "such as personal connection with the instructor and work relationships" (Gendron pers.comm.).

In this context, Elders share the information that they find relevant for each situation. Their interest as a university, Dr. Gendron (pers.comm.) continued, is not to have Elders as 'guest-speakers'. Instead, Elders are an integral part of the courses, engaging with students and offering the opportunity of experienced, hands-on learning. She stressed that whereas learning about indigenous knowledge has a lot to do with textbook learning, they (FNUniv) try to work with Elders and their stories and knowledge in complementarity to chemistry and biology learning, for example. This latter aspect was also associated with the program's way of dealing with – and ultimately minimizing – the implications that arise from the potential for knowledge assimilation present in mainstream education.

6.2 Glocality and place-based environmental education

Integrative Science Program at Cape Breton University. Hatcher et al. (2009b) highlight that "Integrative Science in the classroom relies on a holistic transdisciplinary curriculum firmly based in place" (p. 141). Connection with culture and community, as well as with the cycles of 'Mother Earth' reinforcing and expanding the engagement of the learner and the knowledge, are its crucial elements (Hatcher 2012, Hatcher et al. 2009b). 'Sense of place', however, is described as "a challenging concept to bring into the science classroom because of the transition from an oral tradition to a Western, written one" (Hatcher 2012, p. 349). The transition of the university science classroom in order to accommodate learning from two worldviews, Hatcher (2012) suggests, involves a move from inside to outside in the physical, spiritual and intellectual domains. The

[20] "The Kehte-ayak Elders Council was formed in 2014. The council "provides guidance and shares important indigenous knowledge that informs all of the activities and teaching at the First Nations University of Canada" (FNUniv 2016, p. 4, FNUniv 2017, p. 4).

incorporation of ceremony, preparing the learner to listen and observe, is also an important aspect of this transition (Hatcher 2012).

The core courses of the program – MS-IT courses, inspired by the Mi'kmaw word msit, meaning 'everything together' (Rich 2011) – are described in Rich (2011) based on accounts provided by Dr. Hatcher, one of the main professors in the program. Indigenous knowledge, according to Dr. Hatcher, was mostly present in the lab sessions and Western science, in turn, in lectures (Rich 2011). The first-term course, 'A Sense of Place, Emergence, and Participation', is described as exploring topics such as 'what is Western science?' and 'what is the cultural context of science?' (Rich 2011). Illustrative of its bridging component is Dr. Hatcher's description of a classroom experience where one of the students realizes why the traditional way of eeling – i.e. eel fishing – varies as a function of the season upon being introduced to the life cycle of eels (Rich 2011).

As opposed to 'sense of place' in its common use in environmental studies approaches, the course's 'sense of place, emergence, and participation' encompassed a spiritual connection with the ecosystem or landscape, as explained by Dr. Bartlett (Rich 2011). Hatcher et al. (2009b) describe an illustrative classroom experience of this particular MS-IT course[21]. One student, curious to find out the Mi'kmaq and the scientific names of the blackbirds around her house, discovered that the birds she always thought as blackbirds were actually European starlings. This common name intrigued her, leading her to start talking to Elders. And they told her that the bird was not native. This is described as an eye-opener for her who, together with her children, started observing and documenting all of their local birds to differentiate the native from the non-native ones (Hatcher et al. 2009b). The authors suggests that "she and her children have started the connection with their local environment and with the knowledge of their Elders" (p. 147).

Another course, 'Cycles and Holism', examined interactions (Rich 2011). Hatcher et al. (2009b) provide an example of a classroom experience describing the interplay involving understandings associated with 'sense of place', and local *versus* global implications in the context of this specific course. When studying global ocean currents, students were showed a computer simulation focusing on the trade winds and the Gulf Stream. They also watched a video featuring a catamaran sailor travelling across the Atlantic Ocean and up the eastern coast of North America, pushed by the Gulf Stream. One of the students who had previously spent time as a crab fisherman on the

[21] This and other courses that began to be delivered under the MS IT label in Mi'kmaw communities for students in an access program leading to a Bachelor of Arts degree in 2008 were independent of the originally defined structure for the BSc Community Studies and its Integrative Science component (Bartlett et al. 2012).

Grand Banks is described as being familiar with the warm water current running north off the continental shelf in the area. And "making the connection between his observations aboard the fishing vessels and the global ocean currents was startling to the student. He said that he had no idea what might lead to the warm water current but never thought that it may be generated from so far away" (p. 144). Hatcher et al. (2009b) further describe that this student immediately made the connection to an event that occurred late in a past summer in the Bras D'Or lakes close to his community of Eskasoni. An eddy that budded off the Gulf Stream got into the lakes carrying schools of unusual tropical fish. And as the eddy dissipated, these fish perished in the cold water, becoming a food source for numerous bald eagles. This was portrayed as "a notable and memorable feeding frenzy observation for the people around the Bras D'Or, including the student" (p. 144). Furthermore, these events illustrated to the student "the interconnectedness of many processes that surround him in his place on Mother Earth and how he and his place are connected to and influenced by other places and living things a great distance away" (Hatcher et al. 2009b, p. 144).

Finally, the fourth year 'Wholeness' course is described as originally highlighting health and the human being, which changed to later include notions on the linking of human health and ecosystem health through topics such as remediation projects and environmental impact assessment (Rich 2011).

The role of language in restoring relationships with each other and with the land was also an important aspect of the IS program. Marshall et al. (2010) elaborate on how "mainstream discourse about the natural world has come to favour metaphors of architecture, government, business, and religion. We protect wildlife *corridors*, *regulate* the environment, *manage* land [emphasis in the original] (p. 174)". Largely originating in human abuse of nature, these metaphors represent a language of containment and separation – which is in contrast with indigenous perspectives. According to the authors, "human action has so eroded this interdependency that the language of separation can seem apt, or even wise" (p. 174). One potential way of relearning what it means for humans and nature to be inseparable involves the concept of 'connectiveness'[22] (Marshall et al. 2010). The

[22] 'Connectiveness', as opposed to the more usual 'connectedness' that refers to the state of being connected, works differently based on a closer examination of its last two syllables. The three letters '-ive' imply action, thus 'connective' "speaks of the action essential to being connected [o]r of some thing that participates in that action" (Marshall et al. 2010, p. 179). The next four letters, "-ness", speak of the state or degree of the action. Therefore, 'connectiveness' details the action of becoming connected. "The difference between being and becoming is crucial... for a planet whose citizens have spent the last many generations becoming disconnected, focused, Albert [Marshall, Mi'kmaq Elder] observes, more on rights than responsibilities" (Marshall et al. 2010, p. 179). In Western scholarly discourse, "the idea of connectiveness may most closely resemble inter-or transdisciplinarity, a resonance that accounts in part for the close fit of conneciveness with ideas in cognitive science, complexity theory, and complexity science" (Iwama et al. 2009, p. 5).

authors explain that for the Mi'kmaq peoples in Canada, "language flows from, and determines our treatment of, the natural world" (p. 174). Thus, if language reflects and maintains the boundary of disconnection, it can also help to exchange that boundary for the flow of connectiveness (Marshall et al. 2010).

Furthermore, the program's scope in terms of fostering 'sense of place' went beyond its students through different projects. For example, Bartlett (2011) describes that their first research collaboration – which was funded by the Canadian Institutes of Health Research - Institute of Aboriginal Peoples' Health (CIHRIAPH) – culminated in a three-year project entitled 'Integrative Health and Healing: Co-learning our way to expanding wholeness through restoration of relationships with the land' (Bartlett 2011). According to her, one of the goals of the project was to seek "ways to revitalize traditional Mi'kmaw understandings about interconnectiveness in the cosmos, towards relevancy in the lives of today's children" (p. 182). The creation of numerous sub-projects to help foster a child's sense of place, emergence and participation within nature – thus contributing to "their expanding sense of wholeness within [the] environment" (Bartlett 2011, p. 182) – are highlighted.

Indigenous Environmental Science and Studies Program at Trent University. Kapyrka and Dockstator (2012) emphasize that, according to Leanne Simpson (2002), one of the main concepts[23] associated with respectful and inclusive curricula is the opportunity for student to connect to the land by being on the land. In this sense, Evering and Longboat (2013) describe that "students are encouraged to get out of the classroom and interact with the natural surroundings" (p. 245). They highlight that the Trent University campus – situated on both banks of the Otonabee River in Peterborough, Ontario – is located close to Anishinaabeg First Nations (namely Curve Lake First Nation to the north, Hiawatha First Nation to the south and Alderville First Nation to the south-east). Together with other communities in Tyendinega Kanyèn:ke (Mohawk) Territory and at Six Nations in the Grand River Territory, they provide not only program focus but also placements and research projects for students (Evering and Longboat 2013). One of the second-year courses, Introduction to Indigenous Environmental Studies, is extensively covered in Evering and Longboat (2013) and illustrates in great detail how the program's content can be approached from a place-based

[23] The other three concepts highlighted by Simpson (2002) are: "indigenous knowledges must be the foundation of indigenous environmental education, Elders must be included as experts in program delivery, [and] the programs must be grounded in indigenous pedagogies – utilizing indigenous epistemologies and language in their delivery (Kapyrka and Dockstator 2012, pp. 105-106).

environmental education perspective encompassing cross-scale implications. Its principles are summarized below.

In the Introduction to Indigenous Environmental Studies course, the "principles and values discussed… are intended to support or contribute to the development of a relational paradigm in the discipline of IES [Indigenous Environmental Studies] and our students" (Evering and Longboat 2013, p. 246). The focus of lectures and seminars, the authors continue, is to encourage students "to build relationships with each other and with the human and other-than-human people around them" (p. 246). In doing so, students are also encouraged "to grow or transform themselves, to find or develop their motivation, and to come to know their purpose in life" (p. 246). This learning process is inclusive of considerations on how to behave in the context of relationships, calling upon notions of respect, reciprocity and fulfilment of responsibilities leading to the concept of restoration, which involves restoring human integrity (Evering and Longboat 2013). The principles the authors refer to are: "Indigenous Cultural Knowledge Foundation (From People, Place and Spirit), Relationships With, Relationships Where and Weaving Multiple Knowledges" (Evering and Longboat 2013, p. 246). They are briefly described below.

The **first principle**, Indigenous Cultural Knowledge Foundation, is associated with "the recognition of the importance of indigenous cultural knowledge to the development of (re)new(ed) ways of thinking, being and doing" (Evering and Longboat 2013, p. 247). The course fosters discussions on the "origin and nature of indigenous knowledge as coming from and embodying spirit and human interactions with the natural world" (p. 247). Students become familiar with Haudenosaaunee traditional teachings that serve as a specific cultural knowledge foundation (Evering and Longboat 2013). The authors emphasize that "the unique teachings of a particular people come at a specific time and from a certain place or landscape. These teachings originate from a confluence of people, place and spirit" (p. 247).

The **second principle**, Relationship With, "describes the interconnected spheres of relationships within which we are embedded. These spheres include the human and other-than-human beings with whom we share this land-place-earth" (Evering and Longboat 2013, p. 247). The **third principle**, Relationship Where, is summarized in a biocultural framework embedded in place (Evering and Longboat 2013). It involves the description of a cycle that, for indigenous peoples, begins with an interconnection between place and culture. The authors emphasize that "place is manifested in culture and culture is embedded in place. Culture includes the beliefs people have. Values are intertwined with those beliefs. Attitudes arise out of those values and then precipitate

behaviours" (Evering and Longboat 2013, p. 248). The authors explain that, for many, a strong connection between place and culture is in the past and this often triggers processes that ultimately result in degraded human and environmental health. And they further indicate that for many students, an understanding of this (lack of) connection is invisible. Thus, bringing it into awareness can lead to new thinking. The need and the desire to tackle the impacts of the disconnection also lead to the necessity of weaving together different knowledge systems – which is the **fourth principle** covered in the course (Evering and Longboat 2013).

The need to discuss the 'bringing together' of different knowledge systems, Evering and Longboat (2013) suggest, is based on the recognition that indigenous knowledges and technology have unique contributions to make in finding innovative solutions for complex environmental issues. They conclude that the idea behind the course components "is to invite students to maintain or develop a sense of connection to place along with an understanding of the need to feel and be responsible for respectful relationships" (Evering and Longboat 2013, p. 249). The hope is that students' learning in the course is transformative, leading to a purposefulness in their life choices (Evering and Longboat 2013). IESS (2019) highlights that students enrolled in the Introduction to Indigenous Environmental Studies course for the 2018-2019 academic year mentioned they were grateful for the opportunities that the seminar component offered in the sense of having time outdoors for building their relationship with the land surrounding Trent's campus. Many mentioned that "they had never taken quiet time to introduce themselves to the land" (p. 16) or find ways to offer thanks, "but by the end of the year were able to articulate why those reciprocal relations were important" (IESS 2019, p. 16). For a more detailed description of what the course principles, lectures and seminars entail – or at least, used to back in the early 2010s – refer to Evering and Longboat (2013). Annex V provides an example of a final assignment submitted for this course in the form of a poem, retrieved from IES (2018).

Based on testimonials of graduating students and recent graduates – with either indigenous or non-indigenous ancestry – the program impacts the ways in which they see themselves, engage with others and with the context they happen to be in. Its teachings and training are applied/expected to be applied in a variety of ongoing and/or future activities – e.g. the program providing "the knowledge and skills to promote change in my community" (IESS 2016, p. 29), expectations "to work in my career to include holistic and interconnected ways of thinking into my pursuits as a builder of sustainable technology" (IESS 2018, p. 39) and the IESS program being characterized as "a program of so much unlearning and moving beyond the classroom to consider real world implications" (IESS 2018, p. 40).

Different events are also described that can illuminate the place-based environmental education approach present in the IESS program and its glocal implications. For example, the visit of a Hiawatha First Nation representative who "joined IESS students in the heart of winter to provide a full day of stories and teachings in the tipi[24] and a traditional skill-building walk out on the land surrounding Trent" (IESS 2018, p. 32). Another example, a conference entitled 'Re-igniting the Sacred Power of Creation', focused on "bringing together indigenous teachings and traditional knowledge with a specific focus on addressing complex environmental challenges" IESS (2016, p. 19). The conference is described as having originated from the recognition of "the social and spiritual roots of the current global environmental crisis", where the gathering aimed at engaging "people with original teachings as medicine for restoring our sacred relationships with life, land, air and water" (IESS 2016, p. 19). Participants of the 'Indigenous Perspectives on Protected Areas Gathering' (IESS 2018) are described as having explored "the potential to work together toward the common goals of protecting the natural world and advancing reconciliation between indigenous and non-indigenous settlers and newcomers" (p. 34). Speakers, in turn, encouraged reflection "of the accomplishments, opportunities and challenges relating to establishing protected areas, with a focus on Indigenous Protected and Conserved Areas" (IESS 2018, p. 34). More details about other annual events such as the Temagami colloquium (IESS 2016, 2017, 2018) and Northern Studies colloquium (IESS 2016, 2017, 2018, 2019) can be found in the reports. These events not only entail glocal implications but also bring to discussion aspects associated with Canada's commitment to reconciliation (IESS 2016, 2017, 2018, 2019).

Outreach activities and projects are also important in the context of the IESS program in light of a place-based environmental education approach. The TRACKS (TRent Aboriginal Cultural Knowledge and Science) program is worth looking at. In short, its aim is to stablish partnerships with First Nations, school boards and other non-profits in the Peterborough area to build a stronger community (IESS 2019). Two different but connected programs are at the core of TRACKS: the Outreach & Education Program, and Oshkwazin, a leadership program for indigenous high school aged youth (IESS 2019, 2020). Through both programs, TRACKS youth get to experience various activities related to science and indigenous knowledge systems – largely Anishinaabe and Haudenosaunee (IES 2020).

[24] Evering and Longboat (2013) describe that an outdoor ceremony and traditional teaching area, including a tipi and sweat lodge, are part of the First People's House of Learning (FPHL), "the home of indigenous student services and indigenous campus and community initiatives at Trent University" (IESS 2019, p. 26, 2018, p. 27).

Indigenous Environmental Science Program at the First Nations University of Canada. Dr. Gendron highlighted that the emphasis of the program is on students building relationships with their immediate surroundings and its components – i.e. Saskatchewan plants and animals, indigenous languages that are only found there, and nearby communities. However, Elders are 'brought in' most of the time as opposed to students being taken on the land since local weather conditions imply lots of snow for a considerable amount of time throughout the academic year. 'On the land' activities were mentioned to happen occasionally (during Summer courses that occur sporadically). To illustrate, two activities that take place in the context of her courses were highlighted: walks in the fields that are guided by Elders; and the production of sage[25]-based hand lotion in the lab (Gendron pers.comm.).

Guided walks feature Elders and students on the land, where Elders share knowledge about the identification of plants, their medicinal and ceremonial properties and uses, as well as associated protocols. Sage-based hand lotion production was described as a lab activity where students engage with both the Western/scientific as well as indigenous dimensions of knowledge. Dr. Gendron (pers.comm.) stressed that her contribution takes place in the form of biology and chemistry concepts (e.g. exploring the anatomy of the reproductive organs of flowers, notions on phenology and why determined components mix or do not mix) while the contribution of the Elder comes from the sharing of traditional knowledge and practices. She explained that whilst some of the ingredients are bought from the store (e.g. olive oil and wax), during the activity the Elder explains how the oil and wax would be obtained in a traditional way (from bear grease and "by following the bear[26]", respectively), which results in students being more likely to realize "how resourceful indigenous peoples are and rethink aspects of life that are taken for granted" (Gendron pers.comm.). These realizations were suggested to be more likely to stick to students' minds – as opposed to "reading it in a textbook and forgetting about it" (Gendron pers.comm) – because they are more meaningful as the result of experienced knowledge (i.e. students making the hand lotion by themselves while listening to the Elder's traditional knowledge, together with the faculty who brings in the pertinent Western-scientific aspect of the topic/subject being studied).

Because the focus of the program is mainly offering an 'attractive' introduction to science for indigenous students, Dr. Gendron (pers.comm.) explained that the more 'global' considerations – which include the coverage of concepts such as sustainability – are not very present. Such

[25] Sage was mentioned as a very common plant found in Saskatchewan (Gendron pers.comm.)

[26] Bears are attracted to bee hives to get honey, thus "following the bear" leads to bee wax (Gendron pers. comm.)

conceptualizations occur at a later stage when students move on to programs that are more advanced (and no longer in the FNUniv context but at the University of Regina level). However, thinking about a 'global picture', she mentioned that as more environmental science students are connected to their surroundings in a meaningful way (which is inclusive of not only what is learnt but also how teaching and learning take place), then she hopes that this means a global trend of local connection that leads to a "greater general sense of connectedness" (Gendron pers.comm.).

6.3 Traditional ecological knowledge as common heritage of the humankind: areas of practical significance

For better visualization, a summary of the activities, practices and research happening in the scope of the three programs that were associated with Berkes' (2018) framework is provided in Table 6.1. Detailed descriptions are found below.

Integrative Science Program at Cape Breton University. Bartlett et al. (2015) describe how the IS program expanded from its origins in post-secondary education into the broad science arenas of research, applications, and outreach to youth and community. Some illustrative examples of research conducted in the scope of the IS program – all of them activities with an important outreach component – are thus outlined. They can be associated with sustainability solutions from a place-based environmental education perspective as it connects with areas of practical significance for traditional ecological knowledge as common heritage of the humankind (Berkes 2018), with cross-scale implications.

In the Area of Environmental Ethics, a masters research project aiming at the development of a new environmental education curricula for youth in Nunavut embedded the 'Two-Eyed Seeing' guiding principle (Integrative Science 2011c). Another masters research project can be characterized as being at the intersection of the areas of Environmental ethics, Biological information and ecological insights, Resource management, and Biodiversity conservation (stewardship of biodiversity). Its goals were to learn about Mi'kmaq knowledge on eels – i.e. "how they search for eels [or *kataq* in Mi'kmaw language], when and where they go to harvest eels, how they prepare and eat the eels, how the Mi'kmaw concept of *Netukulimk*[27] guides them in their overall practices to take only what's needed and waste nothing, and also how they have been taught about eels and how they, in turn, teach about eels" (Integrative Science 2011b, p. 1). It also explored

[27] *Netukulimk* is a Mi'kmaw concept and way of life that can be 'translated' into "to provide for oneself and others through all the bounty of Creator" (in Kavanagh 2010, p. 2). Another translation suggested by Hatcher et al. (2009b) is to"develop the skills and sense of responsibility required to become a protector of other species" (p. 146).

Table 6-1*. Environmental science programs and areas of practical significance for traditional ecological knowledge as common heritage of the humankind*

Integrative Science at Cape Breton University		
Initiative (activity, practice, or research)	**Main area of practical significance for TEK as common heritage of the humankind associated**	**Brief description**
Multiple outreach activities (conferences, panels, workshops, symposiums, professional training for indigenous and non-indigenous teachers, among others)	Environmental ethics	Participation of IS-affiliated representatives to introduce, describe and promote 'Two-Eyed Seeing' as a guiding principle to bring IK/TEK and scientific knowledge together.
Masters research project	Environmental ethics	Project aimed at the development of a new environmental education curricula for youth in Nunavut embedding the 'Two-Eyed Seeing' guiding principle.
Masters research project	At the intersection of the Environmental ethics, Biological information and ecological insights, Resource management, and Biodiversity conservation areas	Project aimed at learning about Mi'kmaq knowledge on eels. It also explored how *Netukulimk*[1] can be an interpretive framework for research results.
Senior research fellow's project	At the intersection of Environmental monitoring and assessment, and Biological information and ecological insights areas	Project aimed at exploring modern environmental restoration techniques using the principle of 'Two-Eyed Seeing'.
Senior research fellow's project	Environmental monitoring and assessment	Investigation of the distinct ecological and geological characteristics of the districts of Mi'kma'ki, aimed at forming a framework for effective incorporation of Mi'kmaq traditional knowledge into ecological impact assessments and environmental management decisions.
Undergraduate research project	Biological information and ecological insights, inclusive of Biocultural knowledge revitalization*	Project aiming at learning the Mi'kmaw names for different species of seashells that can be found in Unama'ki[2], where many of these names have not been used for years.
Multilevel project	Biological information and ecological insights, inclusive of Biocultural knowledge revitalization*	Project aimed at helping Mi'kmaw Elders to enlighten their understandings of relational and seasonal patterns in the ecosystem, as well as the interconnections involving Mi'kmaw traditional activities and these natural patterns. Resulted in an eco-calendar depicting the course of one full year in Mi'kma'ki.

Indigenous Environmental Science and Studies at Trent University		
Initiative (activity, practice, or research)	**Main area of practical significance for TEK as common heritage of the humankind associated**	**Brief description**
Mainly the proposal of the Introduction to Indigenous Environmental Studies course	Environmental ethics	Fostering students' mindset shift by inviting them to re-think their 'place' in a context of relationships.
Masters research project	Conservation of protected areas	Aimed at exploring community-based monitoring projects and perspectives on climate adaptation to aid in adaptive and co-management approaches to the planning of marine protected areas. Carried out under the scope of the HEIC Research Group.
Masters research project	Biological information and ecological insights	Through a partnership with the Nunatsiavut Government and the Torngat Wildlife, Plants and Fisheries Secretariat in northern Labrador, the project aims at exploring Inuit knowledge of moose – a 'recent' species in the region.
PhD research project	At the intersection of the Resource management and Development areas, inclusive of Biocultural knowledge revitalization*	Project centered on the transformation of settler-colonial urban planning practices to support the resurgence of indigenous food and governance systems in now urbanized indigenous territories.
PhD research project	Biocultural knowledge revitalization*	Project aiming at the identification – together with community Elders, knowledge holders and practitioners – of the fundamental knowledge(s), skills and pedagogies required within post-secondary programming to support the revitalization of indigenous food systems and indigenous food sovereignty.
PhD research project	Biocultural knowledge revitalization*	Focus on reclaiming, restoring and revitalization of Bodwewaadmii women's water knowledges and practices.
Health, Environment and Indigenous Communities Research Group (HEIC-RG)	At the intersection of several areas	The HEIC-RG hosts research projects that are situated at the interface of social and ecological relationships. Research themes include, among others: understanding critical aspects of Arctic species ecology using both indigenous knowledges and scientific methods; knowledge interaction and integration for policy development and decision making; and community sustainability, health and well-being.
Indigenous Environmental Studies/Science Reading course	At the intersection of several areas	The course allows students to learn more about a topic they are passionate about and perhaps have not been previously exposed to it. Among the topics usually covered, resource management, climate change, and community sustainability are highlighted.

Sustainable Indigenous Communities course	At the intersection of several areas	Upon initial exploration of concepts and the identification of key values that will guide their work, students engage in individual and group work to develop a model of a sustainable indigenous community.
Indigenous Environmental Science at the First Nations University of Canada		
Initiative (activity, practice, or research)	**Main area of practical significance for TEK as common heritage of the humankind associated**	**Brief description**
General program's approach	Environmental ethics	The consideration of IK/TEK perspectives present in the program reflects in sustainability solutions through the mindset shift promoted, where more holistic views lead students to also consider the ecological, cultural, and spiritual values associated with the so-called resources and the contexts where they belong.

* Although not explicitly mentioned by Berkes (2018) when he describes his framework, Biocultural knowledge revitalization is suggested by the author as a potential addition to the list of areas of practical significance for traditional knowledge as common heritage of the humankind.

[1] *Netukulimk* is a Mi'kmaw concept and way of life that can be 'translated' into" to provide for oneself and others through all the bounty of Creator" (in Kavanagh 2010, p. 2). Another translation suggested by Hatcher et al. (2009b) is to "develop the skills and sense of responsibility required to become a protector of other species" (p. 146).

[2] Unama'ki is the "place that European settlers named Cape Breton, Nova Scotia" (Iwama et al. 2009, p. 3).

Source: compilation by the author. For references proceed to the detailed descriptions in the text.

how *Netukulimk* can be an interpretive framework for research results, where the consideration on the concept within the research in the proposed interconnective ways was the suggestion of Mi'kmaq Elder Albert Marshall (Integrative Science 2011b, p. 1). One of the author's insights was that "picturing species at risk through the lens of *Netukulimk* shows declines of most species important in the Mi'kmaq way of life" (Kavanagh 2010, p.2). The participation of the Elder is described as occurring "for the eel", whose populations were declining at that time (Kavanagh 2010, p.2).

In the area of Environmental monitoring and assessment, two projects conducted by a senior research fellow stand out. The first one – which can be characterized as being at the intersection of the Environmental monitoring and assessment area with the area of Biological information and ecological insights – aimed at exploring modern environmental restoration techniques using the principle of 'Two-Eyed Seeing'. In the project description, it is highlighted that Mi'kmaw ethics are guided by a 'Seven Generations concept'[28] and the proposed guiding question was: "how does this mesh with risk analysis associated with contaminant burial or the construction of purifying natural wetlands?" (Integrative Science 2012a, p. 1).

The second project was an investigation of the distinct ecological and geological characteristics of the districts of Mi'kma'ki. The project description states that traditional knowledge associated with these characteristics is like a puzzle, where natural borders govern the outlines of the pieces. The questions proposed were "what are/were the determinants of the natural boundaries of the seven districts?" and "how different are/were conditions for subsistence living within and among these boundaries?". Exploring these questions was aimed at forming a framework "for subsequent effective incorporation of Mi'kmaq traditional knowledge into ecological impact assessments and environmental management decisions in a systematic, effective manner" (Integrative Science 2012, p.1).

Two activities associated with the area of Biological information and ecological insights shared in common a component identified as 'biocultural knowledge revitalization'. This component can be classified as a sustainability solution important to all the areas but that is not explicitly mentioned by Berkes (2018) when he describes his framework. However, the author suggests 'biocultural

[28] The institute worked on a a visual pattern to help explicate the frequently misrepresented concept of 'Seven Generations'. It is available at http://www.integrativescience.ca/uploads/activities/Integrative-Science-Seven-Generations.pdf

knowledge revitalization' as an area by itself that can be added to the list of areas of practical significance for traditional knowledge as common heritage of the humankind (Berkes 2018).

The first activity, part of a project named 'Pattern recognition: Enriching the 'common ground' of bringing Aboriginal and Western scientific knowledges together' aimed at helping Mi'kmaw Elders to enlighten their understandings of relational and seasonal patterns in the ecosystem, as well as the interconnections involving Mi'kmaw traditional activities and these natural patterns (Integrative Science 2008b). A team including IS research assistants worked with many Mi'kmaw Elders, where discussions resulted in the creation of images illustrating relationships and patterns as they develop over the course of one full year in Mi'kma'ki. These images were subsequently assembled into a poster including labels, in both English and Mi'kmaq, of many of the understandings compiled. This eco-calendar poster had close to 5,000 copies distributed locally and internationally (Integrative Science 2008b).

The second activity, an undergraduate research project, was conducted with the help of Mi'kmaw Elders (Integrative Science 2008a). The goal was to learn the Mi'kmaw names for different species of seashells that can be found in Unama'ki, the "place that European settlers named Cape Breton, Nova Scotia" (Iwama et al. 2009, p. 3). Two big challenges to the development of the project are described. The first one was that many of these names have not been used for many years. The second one was that, with the passing of Elders throughout Mi'kma'ki, the 'libraries of knowledge' that they represent are shrinking.

Another important component of the way in which the IS program potentially influenced sustainability solutions was through outreach involving the active participation of Dr. Bartlett and Elders Albert and Murdena Marshall in various environment-related events – e.g. conferences, panels, lectures, courses, workshops, symposiums (Bartlett et al. 2012, Bartlett et al. 2015). Oftentimes, their participation included talks, facilitation, and numerous presentations[29] that occurred during, and after, the time when the program was active. The events covered areas such as forestry, fisheries, water governance, species at risk, sustainability, climate change, reconciliation, and so on. For example, Mi'kmaw Elder Albert Marshall was invited to, and participated in, the 'Mainstreaming Indigenous Knowledge for Sustainability' conference held in May 2011 at The Johnson Foundation in Racine, Wisconsin, U.S. Ascertaining IK-based approaches to natural resource management and education was the purpose of the conference, where discussions based

[29] These talks and presentations are detailed in the "articles and presentations", "activities" and "archives" sections of the former Institute for Integrative Science & Health website, available at http://www.integrativescience.ca/).

on the experiences and personal stories of tribal Elders, educators and natural resource managers focused on the prospects of taking a 'Red Path toward a Green Society' as the means to advance sustainability (Integrative Science 2011a, p.1).

Furthermore, several activities involving IS program faculty, researchers and Elders focused on working towards indigenous and non-indigenous teachers' professional training so that indigenous and non-indigenous pupils of primary and secondary schools could experience consideration of IK/TEK perspectives in the classroom environment (e.g. Bartlett 2009, Hatcher and Bartlett 2009a, Hatcher and Bartlett 2009b, Hatcher et al. 2009, Integrative Science 2012b).

A common aspect of most of these different outreach occasions is the participation of Elders, and/or the Dr. Bartlett, and/or students/researchers associated with the IS program to introduce, describe and promote 'Two-Eyed Seeing' as a guiding principle to bring IK/TEK and scientific knowledge – as well as indigenous and scientific worldviews – together, thus inviting participants to think and re-think about the place of humans in the natural environment via considerations on scientific and indigenous ways of knowing, and how these considerations can be translated into practice in the most diverse fields. Audiences were varied as well, involving both indigenous and non-indigenous participants in indigenous and non-indigenous settings. The Environmental ethics area proposed by Berkes (2018) in his framework resonates best with the general goals of such outreach activities/events.

Indigenous Environmental Science and Studies Program at Trent University. Evering and Longboat (2013) elaborate on how indigenous environmental studies as a discipline "recognizes that indigenous peoples are dealing with, and disproportionately affected by, a growing number of inter-related issues affecting their cultures, communities, traditional territories and the environment at large" (p. 242). All of these issues, the authors continue, culminate in disruptions that affect community sustainability and traditional relationships. Emphasis is given to relationships with foods, medicines and the natural world. Moreover, these issues also lead to environmental and human health degradation, negatively impacting cultural continuance (Evering and Longboat 2013). They stress that many communities are finding ways to tackle these complex environmental challenges, where the IESS program has been playing a role in finding some of the solutions (Evering and Longboat 2013).

Drawing on program reports from 2016, 2017, 2018 and 2019, the following examples of research and courses conducted by IESS faculty and teaching assistants can be associated with sustainability solutions from a place-based environmental education perspective as it connects with areas of

practical significance for traditional ecological knowledge as common heritage of the humankind (Berkes 2018) with glocal implications. At the higher level, however, and with special attention to the Introduction to Indigenous Environmental Studies course previously explored, the area of Environmental ethics plays a major role as it fosters students' mindset shift by inviting them to re-think their 'place' in a context of diverse relationships.

In the area of Conservation of protected areas, one associated masters' project is intended at exploring "community-based monitoring projects and perspectives on climate adaptation to aid in adaptive and co-management approaches to the planning of marine protected areas" (IESS 2019, p. 12). Associated with the area of Biological information and ecological insights, another masters' project focusses on "the role of indigenous knowledge and values in wildlife management under conditions of change" (IESS 2018, p. 9) More specifically, it is explained that through a partnership with the Nunatsiavut Government and the Torngat Wildlife, Plants and Fisheries Secretariat in northern Labrador, the project aims at exploring Inuit knowledge of moose – a 'recent' species in the region since it has been around for no longer than a few decades (IESS 2018).

Biocultural knowledge revitalization[30] is a component present in three PhD projects. The first one, at the intersection of the Resource management and Development areas, is "centered on the transformation of settler-colonial urban planning practices to support the resurgence of indigenous food and governance systems in now urbanized indigenous territories" (IESS 2019, p. 12). The second one, which also includes educational-relevant features, aims at "identifying, in conjunction with community Elders, knowledge holders and practitioner's [sic], the essential knowledge(s), skills and pedagogies required within post-secondary programming to support the revitalization of indigenous food systems and indigenous food sovereignty" (IESS 2019, p. 10). Finally, the third one focusses on "reclaiming, restoring and revitalization of Bodwewaadmii women's water knowledges and practices" (IESS 2019, p. 9).

One research group operates at the intersection of several areas proposed by Berkes (2018). The Health, Environment and Indigenous Communities Research Group (HEIC-RG) hosts research projects that are situated at the interface of social and ecological relationships seeking "to learn about environmental and health issues of importance to indigenous communities across Canada" (IESS 2018, p. 24). Research themes include, among others: understanding critical aspects of Arctic

[30] As previously explained, this component can be classified as a sustainability solution important to all the areas but that is not explicitly mentioned by Berkes (2018) when he describes his framework. However, the author suggests 'biocultural knowledge revitalization' as an area by itself that can be added to the proposed list of areas of practical significance (Berkes 2018).

species ecology using both indigenous knowledges and scientific methods; knowledge interaction and integration for policy development and decision making; and community sustainability, health and well-being (IESS 2018). The project previously associated with the area of Conservation of protected areas is carried out under the HEIC-RG's scope (IESS 2018, 2019).

Finally, two courses operating at the teaching/research interface have potential to exert more of a direct influence on sustainability solutions as they offer undergraduate students the possibility of hands-on learning. The first one, the Indigenous Environmental Studies/Science Reading course, proposes that students learn more about a topic they are passionate about but perhaps have not been previously exposed to it (IESS 2016, 2017, 2019, 2019). Among the topics usually covered, resource management, climate change, and community sustainability are highlighted (IESS 2019). The second one, Sustainable Indigenous Communities, is described as a "research colloquium course that gives students the opportunity to examine concepts of sustainability in a way that is grounded in indigenous knowledge" (IESS 2019, p. 22). Upon initial exploration of concepts and the identification of key values that will guide their work, students engage in individual and group work to develop a model of a sustainable indigenous community. The course is characterized as providing "deep insight into indigenous understandings in the context of addressing contemporary sustainability issues", also encouraging the use of multiple knowledge systems in tackling these issues (IESS 2019, p. 22).

Indigenous Environmental Science Program at the First Nations University of Canada. Given the current early stage of the program, its main objectives, the current few numbers of students enrolled and the fact that no student has graduated yet, Dr. Gendron (pers.comm.) emphasized that she hopes that the consideration of IK/TEK perspectives present in the program are reflected in sustainability solutions, but no illustrative examples were mentioned. She suggested that this potential influence lies on the intended mindset shift that the program fosters, where "more holistic views" lead students to also consider the ecological, cultural, and spiritual values associated with resources and the contexts where they belong. This is expected to play a role when students have to face their own career choices and challenges (Gendron pers.comm.). Thus, the area of Environmental ethics was deemed the most relevant considering how IK/TEK perspectives in the IES program were linked to (potential) contribution to sustainability solutions.

6.4 Summary of challenges, opportunities, and future perspectives

Various challenges arise in the context of inclusion of IK/TEK perspectives in environmental science programs that ultimately can influence sustainability solutions. Especially as they reflect in

ethical implications that arise from the tensions that exist at the 'meeting point' of Western and indigenous worldviews. An important challenge in this sense involves what Elder Albert Marshall associates with 'Hollywood Indians' whereby a tendency for the mainstream to have someone else writing the indigenous representative script – or relegating him/her to entertainment status – is identified (Bartlett et al. 2012, Bartlett et al. 2015). In this sense, a great temptation for people to "just make it up"(Bartlett et al. 2012, p. 332), especially when payment for services is present, is indicated as of major concern (Bartlett et al. 2012, Bartlett et al. 2015, p.). Therefore, these authors argue for the need and importance of review and validation by recognized Elders and knowledge holders of the knowledge that is brought forward – a process described as "akin to the peer-review… required of Western knowledges" (Bartlett et al. 2012, Bartlett et al. 2015, p. 306). A related challenge concerns whether the sources for specific topics within traditional knowledge systems are appropriate (Bartlett et al. 2012).

Kapyrka and Dockstator (2012, p. 109) contend that inherent to the "multi-layered context of working within and between two-worlds", decision(s) of which indigenous knowledges to include pose a challenge because of the immense diversity characteristic of indigenous peoples and, consequently, of the knowledges they keep. They argue that in spite of some general similarities that can be associated with indigenous knowledges around the world, "they are also extremely specific to the peoples and places that hold them" (p. 109). The authors thus recommend that environmental educators acknowledge indigenous peoples and knowledges in whose territories they are located, and start from there. This is explained as a fundamental first step in the process of implementing a 'two-worlds' approach that is based on relationship building between these educators and indigenous peoples.

Students' lack of familiarity, or connection, with nature features among the main challenges that can be associated with the inclusion of IK/TEK perspectives in the environmental science programs studied (Bartlett 2011, Gendron pers.comm., Hatcher et al. 2009a, 2009b, Kapyrka and Dockstator 2012, Rich 2011). This could ultimately affect these programs influence, and potential contribution to, sustainability solutions. Dr. Gendron (pers.comm.) suggested that lack of previous experienced knowledge can be a challenge to be taken into consideration when talking about IK/TEK perspectives present in environmental science programs. She mentioned that, in the context of IES courses, there might be the expectation that students have lived something on the land whereas this might or might not have happened in a way that is meaningful for these courses.

The compartmentalized, discipline-organized and book-based characteristic of Western science – which can be also described as "relying on the observations of others" (Hatcher et al. 2009a, p.6) – is challenging to conciliate with the "personal experience in the natural world" (Hatcher et al. 2009a, p.6) feature of indigenous sciences. Especially acknowledging that indigenous sciences also embeds spirituality, an alien concept to the mainstream branch of the Western-scientific tradition (Bartlett et al. 2012, Hatcher et al. 2009a, 2009b, Hatcher 2012, Kapyrka and Dockstator 2012). This conciliation is explained as problematic especially considering that there tends to be a bias towards particular science disciplines in terms of classroom resources (Hatcher et al. 2009a, 2009b). Hatcher et al. (2009a, 2009b) suggest that in order to meet these challenges, the employment of 'Two-Eyed Seeing' together with indigenous pedagogical resources is valuable. Additionally, she suggests the framing of multidisciplinary science within contexts that are interesting for the students, based on an inquiry-based learning approach that is inclusive of "guided outdoor experiences that reinforce concepts learned in the classroom, learning opportunities in the community, and sessions with Elders and other local knowledge holders" (Hatcher et al. 2009a, p. 6).

Kapyrka and Dockstator (2012) elaborate on their teaching experience to describe that upon being introduced to indigenous environmental perspectives, students "not only become enlightened but also very angry and upset" (p. 106). They explain that students often question why these perspectives were not taught before. The authors suggest that this indicates "the reality of the [general] absence of indigenous perspectives in the Canadian education system… and is indicative of the continued perpetration of colonial practices" (p. 106). However, these students also "become intellectually inspired, spiritually moved, and physically prompted to learn more and/or to 'do something'" (Kapyrka and Dockstator 2012, p. 106).

Rich (2011) describes that, according to Dr. Longboat, "a Mohawk prophecy states that the four sacred colors of people in the world (red, black, yellow, white), each of whom was given a unique set of instructions by the Creator, would one day come back together on Turtle Island[31], to decide whether life will continue or not. Now, knowledge from all peoples is needed" (Rich 2011, p. 99). In this sense, Dr. Longboat further suggests that protecting the integrity of each knowledge is key to the relationship between knowledges since "Western knowledge systems have shown a propensity to want to dominate all other knowledge systems" (Rich 2011, p. 99). These issues are

[31] Robinson (2018) explains that 'Turtle Island' refers to North America for some indigenous peoples. "The name comes from various indigenous oral histories that tell stories of a turtle that holds the world on its back" (Robinson 2018, n/a).

echoed by Kapyrka and Dockstator (2012) when they acknowledge "the risks of bringing cultural knowledges into Western academic spaces and the misrepresentations and/or appropriations that often accompany them" (p. 107).

Concerning racism, it is a challenge that not only it is manifested as a barrier to the inclusion of indigenous cultures in the educational system – especially from educated people – but it can also be associated with the legacy of colonization in its attempted assimilation of indigenous cultures, attributing to indigenous peoples the role of subjects of study and not active generators of knowledge (Hatcher 2012, Hatcher and Bartlett 2010).

Hatcher (2012) and Hatcher and Bartlett (2010) highlight that attempts to give equal time in the classroom to both Eurocentric and indigenous worldviews can be a real struggle, aggravated by the potential reluctance "on the part of experts to become open to the new, to learn, and to transform" (Bartlett et al. 2015, p. 307). Furthermore, Iwama et al. (2009) and Kapyrka and Dockstator (2012) suggest that inclusive educational approaches are no easy task and upon the realization of what approaches such as integrative science requires from willing participants, their numbers can shrink significantly (Iwama et al. 2009).

In a more general sense, Dr. Gendron (pers.comm.) sees conflicts of interest and power dynamics issues as an important limitation hindering the potential contribution of IK/TEK perspectives in environmental science programs to sustainability solutions (e.g. economic development in the way of the implementation of holistic/inclusive sustainability solutions).

Various opportunities were also identified in the context of inclusion of IK/TEK perspectives in environmental science programs that ultimately can influence, and potentially contribute to, sustainability solutions. In the combined words and understandings of Elders Murdena and Albert Marshall, "for the benefit of all humans, our times need to learn to factor the human element into science and to rediscover our humility as but one species on the planet. We must, therefore, be diligent in taking the best from our two worlds: indigenous and Western" (Bartlett et al. 2015, p. 299). Hatcher (2012, p. 285) argues that "transformative education is needed to empower this generation of environmental scientists and practitioners" (p. 354).

Among the 'lessons learnt' that Bartlett (2011) elaborates on, the realization that "universities convey an intellectual authority with which Elders and other traditional knowledge holders may not be able to compete, given today's complex, multi-media world" (p. 4) supports the claim that the role of integrative science is to "help institutions of higher learning to help community Elders

and educators make traditional Aboriginal knowledge real (legitimate, valid, or authentic) in the minds of youth (and many others)" (p. 4). Elder Albert Marshall's sense, in the words of Dr. Bartlett, is that to reach young people "Elders need the university" (Rich 2011, p. 74). Exploring this opportunity, two PhD research projects carried out in the context of the IESS program were identified. One of them aims at broadening the author's understanding of indigenous knowledges, perspectives, and approaches to cross-cultural collaboration so that these insights are applied to the development of educational curriculum and professional development training (IESS 2017). Engaging learners in "understanding how to go about respectful engagement in cross-cultural work that brings together multiple knowledge systems toward addressing environmental issues" (IESS 2017, pp. 9-10) is described as the goal of this curriculum development. The other project, in turn, was based on the author's collaboration with indigenous knowledge holders engaged at Trent and universities in Atlantic Canada (IESS 2017, 2018). The research goals included nurturing indigenous autonomy and governance over indigenous knowledge systems by exploring what practices center indigenous knowledge holders' autonomy, also considering how to operationalize and enact these practices (IESS 2017, 2018).

Kapyrka and Dockstator (2012) highlight the potential for far reaching benefits that the engagement in the tensions that exist between Western and indigenous worldviews entail. These benefits are suggested to serve both indigenous and non-indigenous peoples and, in the context of environmental education, play a role in bringing diverse knowledges and peoples together offering an opportune stage for the future. Described as an inherent decolonizing practice, this approach is suggested as showing the potential "to inform the next generation of environmental educators and scholars at a deeper and heightened level of understanding" (p. 110). Resulting outcomes are characterized as an opportunity to the development of a thorough understanding of the natural world, as well as to yield the resources and capacity to create collaborative solutions to tackle the common environmental challenges of all of humanity and the Earth – now and into the future (Kapyrka and Dockstator 2012). In short, and in more technical terms, IK/TEK can offer a more elaborated perception of risk.

Programs' successes are also highlighted as opportunities for the indirect assessment of the influence of consideration of IK/TEK perspectives in environmental science programs on sustainability solutions. Bartlett et al. (2012) elaborate on the achievements of the IS program, which are described as 'remarkable' while the program functioned within its original visions. 27 Mi'kmaw students have graduated with a science or science-related degree from CBU, 13 of them from the BScCS degree's Integrative Science concentration, while less than five without IS

affiliation had/have ever graduated before or during the same time period (Bartlett et al. 2012). Most of them are described as holding key positions in their communities after graduation (e.g. school principal, research scientist or assistant, natural resource manager, nurse, teacher). About 100 Mi'kmaw students experienced first-year MS-IT courses. And the authors describe that echoing Elder Albert Marshall's perspective that 'seeds germinate when the environment is right'[32], many of the 100+ students could awake later in life to the teachings even from a short exposure to IK/TEK in ways that they will likely never know (Bartlett et al. 2012). As for Trent's IESS, student enrollment (i.e. total number of students in IESS courses) shows an overall increasing trend, growing from around 50 students in 2000-2001 to around 300 in 2018 (IESS 2018).

E-learning also arises as a challenging opportunity for educational systems in general – and it would not be different for environmental science programs that are inclusive of IK/TEK perspectives. Ferreira et al. (2014) contend that although the best way to engage with traditional knowledge is by spending time with Elders on the land, this is not always possible. Evering and Longboat (2013) also mention that, sometimes, students cannot participate in person in events and talks with Elders. An alternative is thus the provision of recorded material to students (Evering and Longboat 2013, Ferreira et al. 2014). When talking about a specific instance where recorded material is used at FNUniv, Ferreira et al. (2014) explain that "viewing these clips is often a first glimpse at traditional knowledge" (p. 6) for most students, indigenous and non-indigenous, who have no contact with Elders. The authors further suggest that advantages and disadvantages of online teaching and learning fall on a spectrum. E-learning can be regarded as a valid means of increasing the accessibility of underserved students to higher education (Ferreira et al. 2014). But in the context of the IES program, for example, "access to a computer and internet connection is sometimes an issue with indigenous students" (Gendron pers.comm.). Ferreira et al. (2014) also stress the need of a careful approach to online resources as it connects to science teaching and learning in terms of the acknowledgement and inclusion of indigenous sciences. For example, Gendron (pers.comm.) explained that while some Elders are comfortable with e-learning platforms, tools and resources, others are not.

Ultimately, challenges in the sense of "inconsistencies and insufficiencies at the administrative, faculty, budgetary and recruitment levels" (Bartlett 2012, p. 41) led the Integrative Science program

[32] "Every year, the ash tree drops its seeds on the ground. Sometimes those seeds do not germinate for two, three or even four cycles of seasons. If the conditions are not right, the seeds will not germinate. Sometimes… you have to be content to plant seeds and wait for them to germinate. You have to wait out the period of dormancy. Which we shouldn't confuse with death. We should trust this process" (words of Elder Albert Marshall when asked whether 'Two-Eyed Seeing' works – in Bartlett et al. 2015, p. 289).

and the BSc Community Studies at CBU to extinction in the late 2000s. Bartlett et al. (2012) emphasize that "environmental (institutional and community) politics can and do profoundly influence the resourcing and recruitment of an academic program and can help foster success or sabotage it" (p. 335). However, the latest updates available on the Indigenous Affairs webpage of CBU indicate that the Unama'ki College[33] is currently developing "a new undergraduate program based on the concept of 'two eyed seeing' to build on the positive experience of Integrative Science programming" (CBU 2020, n/a).

In its latest report (IESS 2019), the IESS program is described as "rapidly growing in terms of partnerships, community involvement and student enrollment" (p. 32). It is currently anticipated that students will be offered the possibility to diversify their experiences based on five different themes, namely "Indigenous Foods and Medicines, Indigenous Peoples Health and the Environment, Natural Resource and Ecological Restoration, Environmental Planning, and International Environmental Network"(IESS 2019, p. 32). Additionally, the recently inaugurated Indigenous Environmental Institute – which was "established with full support from Trent University's administration and the Schools of Environment and Indigenous Studies" (IESS 2019, p. 25) – is described as fostering the accessibility of the multiple knowledge-system approach used in the IESS program to audiences outside the university via professional training, adult education, and community-based research (IESS 2019).

Finally, Dr. Gendron (pers.comm.) highlighted that one important activity – that can be associated with the future of the IES program – is community engagement via regular visits of high school students. These visits are meant to show FNUniv, its courses and facilities, as a small community made of people who are there to support their students as opposed to a hostile environment, a common view about the university that is shared among some students. According to her, the goal is that these visitors develop a higher interest in thinking about university studies as a possibility for them. Through programs such as the IES, she hopes that the mindset shift promoted by university programming inclusive of IK/TEK perspectives results in more sustainable decisions and choices by students/graduates in their future careers. For example, if they are to decide how to explore/develop a given area, they are more likely to see it beyond "oil and gas" and also consider the animals and plants that exist there, the relationships, the sacred, ceremonial, and livelihood characteristics (Gendron pers.comm.).

[33] For more information on the history of the Unama'ki College and its links with the Integrative Science program, refer to https://www.cbu.ca/indigenous-affairs/unamaki-college/our-history/

7 Discussion

The interpretation of results is detailed in the following subsections, answering this study's guiding questions.

7.1 How is traditional ecological knowledge represented in selected academic programs?

The representation of TEK in the IS, IES and IESS programs takes place via the embracing of ontological and epistemological pluralism that manifests in knowledge bridging approaches. In other words, TEK representation occurs in academic environments that acknowledge indigenous and Western worldviews as they reflect different assumptions concerning the nature of reality (i.e. ontologies); different assumptions concerning the nature of knowledge about this reality (i.e. epistemologies); and, finally, allow for these different worldviews to be present in inclusive teaching/learning dynamics. Knowledge bridging approaches include 'Two-Eyed Seeing' as a guiding principle in the context of the late Integrative Science program offered at Cape Breton University (e.g. Bartlett et al. 2015); a 'two-worlds' approach in the context of Trent University's Indigenous Environmental Science and Studies program (Kapyrka and Dockstator 2012); and, finally, instructors as facilitators of bridge-making in the context of the Indigenous Environmental Science program offered at the First Nations University of Canada (Gendron pers.comm.). These inclusive dynamics encompass considerations on **who** speaks for the knowledges put forward, an aspect that is sensitive to concerns about knowledge integrity and appropriate knowledge representation.

The IS, IESS and IES programs attempt to have indigenous Elders and knowledge holders involved with the teaching of/about indigenous knowledge. Whether the teachings are of indigenous knowledge or **about** indigenous knowledge is trickier to assess and report on. Following Berkes (2018, pers.comm), the presence of IK/TEK in the programs would be mainly characterized as teaching about it since the 'on the land, apprenticeship style' aspect of the teaching/learning relationship is not so present. Even if indigenous Elders and knowledge holders are transmitting their knowledges in an oral form, this is unlikely to reflect part of a way of life and lived experience when happening in a classroom setting.

The 'source' of the indigenous voice as problematized by Rich (2012) can be said to come from proper representatives – at least as indicated in the data sources assessed. Considerations on appropriateness reflect challenges (e.g. 'Hollywoodian Indians' in Bartlett et al. 2012 and Bartlett et al. 2015) and the acknowledgement that indigenous knowledges are varied within and among communities (Bartlett et al. 2015, Kapyrka and Dockstator 2012). Based on Levac. et al. (2018),

this acknowledgement is critical to point out since they identify that the diversity in question is often overlooked when it comes to discussions on linking indigenous and Western ways of knowing. These considerations are important because of the tendency of the mainstream to assimilate/appropriate indigenous knowledge, as identified in the challenges within the programs investigated as well as described in the literature review in a broad context (e.g. Berkes 2018, Mistry and Berardi 2016, Rathwell et al. 2015, Tengö et al. 2017) and in the university context (e.g. Koty 2014, Levac et al. 2018, Nakata 2002, Rich 2012). Additionally, they point to the question on whether there is one way of bridging knowledge systems in academic settings or it requires a case-by-case approach given the differences of locally rooted TEK systems.

Two-Eyed Seeing, for example, can be applied to very diverse contexts. But at the same time, it does not imply one specific indigenous or scientific way of knowing by default, and thus it is built case-by-case depending on the context where it is applied. Additionally, it is but one linking framework for collaboration across knowledge systems (e.g. Levac et al. 2018, although focusing on collaborative research, list 19 linking frameworks and Two-Eyed Seeing is one of them – Annex I). Therefore, Tengö's et al. (2017) evidence-based guidance on how the tasks to mobilize, translate, negotiate, synthesize and apply multiple evidence in bridging indigenous and scientific knowledges can guide future research in this direction. Although they focus on international science-policy processes (such as the IPBES) and the role of knowledge bridging in enhancing governance for sustainability, they also emphasize that successful collaboration across diverse knowledge systems has in its core the engagement of actors and institutions in equitable and empowering knowledge-sharing processes. And this speaks directly to calls for the decolonization of universities (Hall and Tandon 2017), also relevant to the contentious reconciliation agenda for Canadian higher education (Courchene 2019, Gaudry and Lorenz 2018, Jung 2018, Pidgeon 2016).

Resistance and reluctance of 'experts' to transform the classroom experience in order to be inclusive of worldviews other than the Western's as well as institutional tensions as the result of inclusive approaches were mostly covered in literature associated with the IS program (e.g. Bartlett et al. 2012, Bartlett et al. 2015). Since this program "floundered" in the late 2000s (Bartlett et al. 2012, p. 333), and considering the current reconciliation rhetoric present in universities (Gaudry and Lorenz 2018, Tamtik and Guenter 2019), this indicates that this barrier is less influent for the IESS and IES programs. In fact, the establishment of the Indigenous Environmental Institute in the context of the IESS program – described as receiving "full support from Trent University's administration" (IESS 2019) – and the whole institutional environment of the FNUniv as detailed in its latest available reports (FNUniv 2016, 2017) suggest a welcoming atmosphere towards

indigenous ontologies and epistemologies at the greater institutional level where these programs are embedded.

Bartlett's et al. (2012) argument is enlightening in this respect, indicating that "environmental (institutional and community) politics can and do profoundly influence the resourcing and recruitment of an academic program and can help foster success or sabotage it" (p. 335). The very floundering of the IS program was associated with low recruitment levels and happened quite close in time to when Dr. Bartlett and Elders Albert and Murdena Marshall left their roles at CBU (Bartlett 2012, Bartlett et al. 2012), illustrating the risks of reliance on individual champions as pointed out by Hagan and Huijser (2008). Hence the need of inclusive programs being part of an ongoing institutional commitment, or a whole-of-institution approach, where multiple actors in different levels are engaged (Hagan and Huijser 2008).

Considering the overall picture of reconciliation in universities as indicated by Gaudry and Lorenz (2018), especially concerning the differences in theory/rhetoric and practice, future research could better investigate reconciliation dynamics in Canadian universities by focusing on the institutionalization of IK/TEK through the lens of institutional theory. The analytical approach suggested in the "integrated theoretical account of how to study and interpret the ongoing changes in the higher education field" of Frølich et al. (2013, p. 89) could be used to compare and contrast internal and external factors that influence the institutionalization of IK/TEK perspectives in environmental science programs, other programs, departments, institutes, and single (or groups of) universities.

The inclusive process characterized by IK/TEK perspectives in the IS, IESS and IES programs indicates a move towards transdisciplinarity. And a transdisciplinary approach is described as required for universities to work as catalyzers of the transition towards sustainability, also answering the calls for the decolonization of academia in the context of ESD (Hall and Tandon 2017, Koty 2014, Leicht et al. 2018, Stephens et al. 2018, Waas et al. 2010). Furthermore, these programs represent a move in the academy to welcome indigenous knowledges, worldviews and peoples as well as a suitable setting where indigenous knowledge and the core identity of environmental science programs meet to the extent that both are concerned with "the healing of the relationship of humans with the Earth, the linking of learning with responsibility, and the long-term view necessitated by sustainability goals" (Rich 2012, p. 315).This is so especially considering IESS's students accounts of the program (e.g. IESS 2016, 2018) and Dr. Gendron's vision for the way in which the IES program promotes a mindset shift in its students (Gendron pers.comm.).

Based on the detailed course descriptions present in the programs' literature (particularly Evering and Longboat 2013, Hatcher et al. 2009b, Rich 2011), the IS and IESS programs promote students self-awareness as they are encouraged to reflect on who they are and what roles they play in relation to others as well as their environments, also including considerations on knowledge revitalization as indigenous students reconnect with their ancestry. This is best illustrated – in the context of the IS program and additional to the classroom experiences previously described – by Dr. Hatcher when she recalls a specific classroom event that followed the introduction to the medicine wheel (Rich 2011). She describes how one student revealed that, as a young Aboriginal person, she had been exposed to those teachings before but together with her fellow students, they dismissed it. Upon seeing it as something worthwhile being discussed at the university level, however, "it just overturned all that dismissal of her own culture and who she thought she was. It changed her whole way of looking at things" (Dr. Hatcher quoted in Rich 2011, p. 74). This event is also illustrative of Elder Albert Marshall's sense that "Elders need the university" (Rich 2011, p. 74). In this regard, it evidences IK/TEK perspectives in university programs as an empowering tool for indigenous peoples as indicated by Hauser et al. (2009), Koty (2014), Pidgeon (2016), and Rich (2012), inclusive of considerations on higher education indigenization by Pidgeon (2016) and illustrative of reconciliation indigenization based on Gaudry and Lorenz (2018) – though the scope of these latter authors encompasses universities as a whole, and the subjects of interest here are individual programs and their associated courses.

The origins of both the IS and IES programs share the goal to attract, and most importantly, retain, indigenous students to post-secondary science education, whereas the IESS program serves more non-indigenous than indigenous students – but indigenous students nonetheless describe their IESS experience as positive[34] (Bartlett 2011, Bartlett et al. 2012, Bartlett et al. 2015, Gendron pers.comm., IESS 2016, 2017, 2018). These aspects can be directly associated with important features of indigenization of the academy and the empowerment of indigenous students (Gaudry and Lorenz 2018, Hagan and Huijser 2008, Hauser et al. 2009, Koty 2014, Pidgeon 2016, Rich 2012). But they also touch upon the problematization described by Jung (2018) in the context of the potential for further draining indigenous communities of their future as the result of programs focusing on indigenous youth employment.

[34] The observation and reproduction of students' accounts, especially indigenous students, on their positive experience in the IESS program acknowledges the limitations inherent to the data sources used (i.e. program reports on the program website whose purpose, among others, is to promote the program for future student recruitment).

Jung (2018) describes that in light of the Canadian government framing of reconciliation as a path to economic growth, this vision "appears to foreground resource extraction and better incorporation of indigenous people, especially youth, into the workforce" (p. 254). She acknowledges the benefits of economic reconciliation as it enables constitutional rights, profit sharing, and the re-shaping of extractive industries in ways that better reflect indigenous commitment to good stewardship of the earth. However, she also points to the risks of indigenous peoples being compelled to adapt to existing structures, where the focus on indigenous youth employment as a priority for renewed relationships between the Canadian government and indigenous peoples translates into numerous training and mentorship programs. And although drawing indigenous youth into the workforce may alleviate widespread indigenous poverty and high unemployment levels, most of the labor opportunities they might be trained for imply distancing from their communities, posing a risk to the already threatened inter-generational processes of language and culture transmission (Jung 2018). These processes described by the author were not explicit in the investigation of the IS, IESS and IES programs – actually, quite the opposite. Nevertheless, they are important to consider as they are associated with fostering indigenous recruitment in higher education. And if training, mentorship, and higher education programs are inclusive of IK/TEK perspectives and geared towards building a sense of place, the potential harm identified by Jung (2018) could be minimized – especially considering that one of the main areas for indigenous youth recruitment she points out is natural resource management.

Programs grounded in traditional ecological knowledge must by definition be place-based. Exploring how this relates to global perspectives requires an investigation of cross-scale interactions. Based on this study's approach, the connections between the global and the local are more present in the IS and IESS programs but they manifest in different ways. The IS program focused on Mi'qmaw students and their understanding of local processes and how these influence and are influenced by global processes. Especially the excerpts on students' realization of why eeling practices change throughout the year (Rich 2011) and understanding of the Gulf stream dynamics (Hatcher et al. 2009b) can be associated with a knowledge bridging approach that explores complementarity (Berkes 2018). The IESS program, in turn, operates with a greater number of non-indigenous students (IESS 2018) coming from more diverse backgrounds and tries to bring in the local knowledge of diverse indigenous groups, thus working towards establishing parallels across similar issues that affect different communities in different places. Notions on (un)sustainability (e.g. considerations on the roots of the global environmental crisis in courses and events) are also present (IESS 2016, 2017, 2018, 2019). The IESS program, therefore, can be said to be more in tune with the increasing interest in environmental and sustainability scholarship on

indigenous knowledge and knowledge bridging to tackle the challenges of, and devise solutions to, the ongoing global social-ecological crisis (e.g. Berkes 2018, Koty 2014, Leicht et al. 2018, Levac et al. 2018, Mistry and Berardi 2016, Rathwell et al. 2015, Tengö et al. 2017).

7.1.1 Indigenous knowledge representation and emergency e-learning: initial insights

Sensitive to issues on knowledge representation and characterized as a particularly challenging opportunity for educational approaches inclusive of IK/TEK perspectives, e-learning implications are timely to lay out. In light of the unfolding COVID-19 pandemic and the consequent subtle move to widespread e-learning resources, tools and platforms, some reflections relevant to the IESS and IES programs might also apply to other programs with similar approaches. And although this will be subject to much discussion in the months and years to come, some initial insights are detailed below.

E-learning resources were described as part of classroom dynamics in the IS programs (i.e. computer simulation of the Gulf Stream in Hatcher et al. 2009b). In the IESS program, these resources as suggested as an alternative if students could not attend talks and events with Elders in person (Evering and Longboat 2013). As for the IES program, they consist of both an alternative to occasions where being on the land is not possible (Ferreira et al. 2014) as well as a flexibility option through the offering of some online courses (FNUniv 2020, UR 2020d). Now, the emergency need for universities to resort to remote teaching/learning activities is certainly affecting the dynamics of the IESS and IES programs.

The implications of emergency e-learning, especially with regards to the securitization of education, are explored by Murphy (2020) as this conversation only begins. The World Bank (2020) is calling on education leaders and stakeholders to better investigate the changes incurred in the ongoing rapid transition to online platforms for teaching and learning, asserting that these changes "must be studied for efficacy and to understand best what works and does not and for whom" (p. 9). The International Association of Universities (IAU 2020) is continuously working on the compilation of information about the latest developments concerning the impacts of the COVID-9 pandemic on universities. Additionally, they are currently working on the identification of the major challenges that higher education institutions face in the short, medium, and long term, aiming at the development and sharing of solutions (IAU 2020).

The main question that arises with regards to programs such as the IESS and IES in this context is to what extent e-learning can foster or undermine the broad educational commitment of these programs to include IK/TEK perspectives in curricula – as well as programs' goals and

philosophies. This question is also sensitive to the discussion on whether inclusive programs work with the teaching of IK or the teaching about IK – aggravated by the prospects of even more restricted in person and on the land interactions.

If on the one hand e-learning has the capacity to reach a greater number of students – including indigenous students living in isolated/remote areas (Ferreira et al. 2014), on the other hand some of these students also face difficulties accessing computers and internet connection (Gendron pers.comm.). The engagement of Elders in classroom dynamics is also subject to further investigation since some of them feel comfortable with e-learning practices while others do not (Gendron pers.comm.). There is the need to better understand Elders' and traditional knowledge holders' accounts of recorded talks, live transmissions, and other e-learning resources. This echoes the concerns raised by The World Bank (2020).

Another important question refers to what extent e-learning may lead students to further 'disconnect from', or better 'connect to', their surroundings and the environment in general. E-learning may worsen the main challenge of both place-based environmental education approaches as well as attempts to bridging indigenous and Western knowledges in environmental science education as students become more oblivious of the world beyond screens. But it can also be part of an enhanced sense of connectedness as communities become more isolated and use technology focused on their own realities, what can be conducive to the development/maintenance of localized knowledge. Furthermore, one instance does not exclude the other and mixed responses in a diverse world are perfectly feasible. Context-specific investigations can further examine this by answering questions such as 'how can IK/TEK perspectives play a role in teaching about IK as the means to minimize e-learning driven further disconnection?' And 'at what cost? – i.e. is it harmful to traditional/indigenous knowledge systems? How?'. Also 'what are the possible ways to minimize potential harm and enhance the strengths associated with e-learning resources used in inclusive educational programs?'. Evering and Longboat, for example, mention that when students are not able to attend in person talks given by Elders, they are encouraged to reflect on, and describe, "how a non-participatory listening event is different from [the] ones they experience in person"(p. 253). This reflection exercise, however, only applies when students experience both in person and recorded participation. In this e-learning dimension, live transmissions could offer the possibility of interaction but the 'experience on the land' aspect of IK/TEK would pose an even greater challenge to the teaching/learning practice. Additionally, access to computers, internet connection as well as the ability to navigate these resources are required from instructors and students.

The potential questions above are mere suggestions. They could and should be subject to further scrutiny, critically analyzed, adapted, improved, and/or expanded, thus resonating with The World Bank's (2020) calls, and/or reflecting IAU's (2020) developments. A final thought, however, is that e-learning should be seen as what it is: a tool. And as such, its uses and outcomes tend to be less about the features of the tool itself and more about the ways in which the tool is used.

7.2 What is the potential contribution of these programs' engagement in knowledge bridging to sustainability solutions?

The contribution of programs' engagement in knowledge bridging to sustainability solutions, based on this study approach, is expressed in the ways and areas that courses, research projects and outreach activities bring about their action-oriented components. The area of Environmental ethics is present and plays a major role in all programs assessed in the sense of how consideration of IK/TEK perspectives influence sustainability solutions (Table 6.1). This area was identified as of relevance for all the programs' courses and, for the IS and IESS programs, also present in research projects and other outreach activities.

Environmental ethics by and large dictate how relationships within and towards the environment are framed, reflecting the conceptualization of humans either as in charge of the natural environment in the dominant Western worldview; or part of a natural environment according to indigenous worldviews (e.g. Berkes 2018, Levac et al. 2018, Rich 2012). And these understandings, together with the development of connections to beings and places, play a major role in how knowledge is manifested in applied initiatives that constitute the practical aspect of sustainability solutions in a variety of areas. In this study, these areas include the remaining 7 areas listed by Berkes (2018), plus biocultural knowledge revitalization.

Based on the activities assessed via reports and other miscellaneous files, consideration of IK/TEK perspectives influence sustainability solutions mainly via research projects in the context of both IS and IESS programs. Their goals and approaches, as described in the documentation consulted, allowed for their classification in Environmental ethics and other six areas listed by Berkes (2018), plus biocultural knowledge revitalization (Table 6.1). The only area not explicitly represented in the activities/projects uncovered was Dealing with disasters and modern crises. Acknowledging the limitations of the data collection and analysis protocols, this finding cannot be interpreted as an indicative of the area not being present in the programs. In other words, there is the possibility that activities and projects in the programs do foster sustainability solutions in this area but they were not present, or not properly identified, in the documentation analyzed.

Evidence points to knowledge bridging taking place by design in the context of both IS and IESS programs. For projects using 'Two-Eyed Seeing' as a guiding principle, this is so because the very principle is a knowledge bridging approach by itself. For the IESS's projects, especially those under the HEIC-RG, research takes place in accordance with the group's commitment to answer to communities' needs, engaging with them in the process (IESS 2018). Projects featuring a Biocultural knowledge revitalization component seem to implicitly support knowledge bridging by pursuing the recovery of non-written knowledge to then bring it to light in various forms, including visuals (e.g. posters) and content for students within the programs as the authors are also course instructors and teaching assistants (IESS 2016, 2017, 2018, 2019). In the context of IESS's projects, the 'revitalized' knowledge can also be associated with an indigenous empowering approach. Furthermore, concerns about inclusive post-secondary programming are very present in the IESS research effort, ultimately reflecting in sustainability solutions as they incorporate environmental ethics implications.

Overall, the great majority of projects in the IS program focused on the Mi'kma'ki territory and the Mi'kmaq people – the place where CBU is located and the place from where the students the program was designed to attract come from. IESS's projects are more varied in this regard. Moreover, outreach activities in the context of the IS and IESS programs can be characterized as extending beyond programs' students and are inclusive of indigenous children and youth, important aspects in the discussion of the role of universities as catalyzers of the transition towards sustainability and UNESCO's proposal of broader community engagement for ESD and the development of local solutions (Leicht et al. 2018, Stephens et al. 2008), also working as instruments promoting the reconnection of youth with traditional and ancestral knowledges and illustrating in an yet another way Elder Albert Marshall's sense that "Elders need the university" (Rich 2011, p. 74).

Although not the focus of my proposal given its scope and time constraints, the IS, IESS and IES programs show in common a characteristic of linking environmental health and indigenous health. The IES program is inclusive of this notion based on the accounts of teaching/learning activities focusing on medicinal plants and attempts to foster students' realization of meanings, uses, protocols and ceremonies associated with them (Gendron pers.comm.) The IS and IESS programs, in turn, present course content, research effort and general commitment to the area of environmental health (e.g. Bartlett 2011, Bartlett et al. 2015, IESS 2016, 2017, 2018, 2019, Marshall et al. 2015, Rich 2011). Perhaps one potential contribution of how consideration of IK/TEK perspectives in environmental science programs influence sustainability solutions is this 'bridging'

of peoples' health and the health of their surroundings – i.e. individual health situation as a reflection of the health of the environment, and vice-versa. Elder Albert Marshall's understanding[35] is that this may start from a (renewed) environmental ethics perception that is inclusive of interconnectedness (Bartlett et al. 2015, Marshall et al. 2010). Hatcher (2012) sums it all up in the following statement: "we seem to be disconnected from our Mother Earth, applying band-aid approaches to problems which require major surgery. Perhaps this major surgery involves a shift within ourselves, reconnecting with our support system in a meaningful way to re-develop a sustainable course for the future" (p. 355).

The conflicts of interest and power dynamics issues identified by Dr. Gendron (pers.comm.) as an obstacle for the contribution of IK/TEK perspectives in environmental science programs to sustainability solutions speaks directly to the prevalence of 'a language of separation' identified by Marshall et al. (2010) that translates in the dominance of the Western worldviews in terms of humans being 'in charge' of nature (e.g. Berkes 2018, Rich 2012) as opposed to concerned with the fulfilment of their role in their relationship with nature (Wilson 2001 in Levac et al. 2018). And although Berkes (2018) identifies a recent surge in knowledge coproduction for problem-solving in areas characterized by critical environmental issues, the current unfolding of the COVID-19 pandemic poses an extraordinary challenge.

The roots of the coronavirus crisis have been associated with the destruction and exploitation of nature (e.g. Shield 2020, UNEP 2020a, 2020b, Vidal 2020), and its development is leading the contemporary society to an unprecedented socioeconomic crisis (e.g. Nicola et al. in press). In this context, whether conflict of interests and power dynamics issues in the way of the implementation of inclusive and holistic sustainability solutions will persist or transform is yet to be seen. The calls for a more resilient, equitable and green economic recovery, however, bring some hope in the sense of humanity's choice for a more transformative path (e.g. Gilio-Whitaker 2020, IISD 2020). But it will nonetheless require massive efforts from important actors. And some of them, at least for now, are more tuned to business as usual quick-fix solutions (Harrabin 2020). Future research could focus on how all these factors will reflect in educational systems worldwide – especially post-

[35] Words of Elder Albert Marshal, in Bartlett et al. (2015, pp. 288-289): " If the environment is not healthy, how can we expect to be healthy?... We keep expecting the pharmaceutical and biotechnology companies to come up with a magic pill to relieve us of our health problems ... what we need to come to better realize is that we are the magic... Schools need to put "natural science" back into the forefront of curricula at all levels as only this will ultimately give us our good health back ... because only when we come to realize that everything that we do to the water, the air and the earth, we also ultimately do to ourselves ... will we treat our environment and ourselves with equal reverence ... and only with the understanding that all must be maintained and that all must be equal, will we be healthy. This is the path of understanding that will lead us to good health and wellness – for humans and all others in our environment and the Earth herself'.

secondary programs inclusive of IK/TEK perspectives and in addition to the impact of an accelerated and emergency-driven transition to e-learning platforms as previously described. Perhaps the work of François (2015) on glocal higher education and associated frameworks can provide some guidance to initial steps in this direction.

8 Conclusion

I would like to start the beginning of the end of my thesis with the following quote:

> Perhaps the singular fundamental lesson of traditional ecological knowledge is that worldviews and beliefs do matter. Almost all traditional ecological knowledge systems may be characterized as a complex of knowledge, practice and belief. Almost universally, one encounters an ethic of nondominant, respectful human-nature relationships, a sacred ecology, as part of the belief component of traditional ecological knowledge (Berkes 2018, p. 276).

This study illustrated that the representation of traditional ecological knowledge in three Canadian environmental science programs occurs in academic environments that acknowledge indigenous and Western worldviews as they reflect different assumptions concerning the nature of reality (i.e. ontologies) as well as the nature of knowledge about this reality (i.e. epistemologies), allowing for these different worldviews to be present in inclusive, place-based teaching/learning dynamics. Bridging approaches include 'Two-Eyed Seeing' as a guiding principle in the context of the late Integrative Science program offered at Cape Breton University; a 'two-worlds' approach in the context of Trent University's Indigenous Environmental Science and Studies program; and, finally, instructors as facilitators of bridge-making in the context of the Indigenous Environmental Science program offered at the First Nations University of Canada.

Considerations on who speaks for the knowledges put forward in front of the great deal of diversity within and among indigenous communities were highlighted. The potential role of these programs – or at least, their principles – in mitigating harmful impacts to indigenous communities in a context of economic reconciliation that seeks to incorporate indigenous youth to the workforce was suggested. And considering how the interactions of local with global implications are reflected in these programs, from the current COVID-19 pandemic arises the need for emergency transition to e-learning platforms that pose additional challenges to academic programs grounded in traditional ecological knowledge.

Findings also showed that the contribution of programs' engagement in knowledge bridging to sustainability solutions is expressed in the ways and areas that courses, research projects and outreach activities bring about their action-oriented components. A renewed environmental ethics emerging from programs' experiences stands out as playing a major role in determining how relationships within and towards the environment are framed. These understandings, together with the development of connections to beings and places, manifest in applied initiatives that constitute the practical aspect of sustainability solutions in a variety of areas.

Although the emphasis on environmental ethics might not indicate an extraordinary finding, it does lend itself to thorough reflection not only about where the human enterprise is going but also, and perhaps most importantly, about how the journey unfolds. And I am convinced that if we are to witness a significant turn into a more sustainable path, a respectful human-nature relationship is not only advised – it is needed. And this is particularly relevant since a mindset shift fostering a more widespread perception of human health and environmental health as interconnected, or bridged, would fit well to the prospects of evolution for, and the world after, the ongoing COVID-19 outbreak.

As a final thought, I reflect on the past two years of learning and bring back one of the very first readings in the context of the MESPOM program, Lynn White's 'The historical roots of our ecologic crisis' article from 1967 (White 1967). Acknowledging the tensions inherent to the author's use of the term 'religion' (for him, "human beliefs about our nature and destiny", p. 1205, elaborating on the influence of Christianity and strongly criticizing the view that "nature has no reason for existence save to serve men", p. 1207, adopted by western variations of the Christian faith), it is not my intention to problematize this discussion – this is beyond the scope of my research as well as of my expertise. But to the extent that I am finishing the program writing a thesis on indigenous knowledge in the academy and proposing to look at sustainability solutions influenced by this move while the world is in turmoil, I see that White's (1967) claim that "more science and more technology are not going to get us out of the present ecologic crisis until we find a new religion, or rethink our old one" (p. 1206) reflects quite well the dimensions of our current social-ecological challenges aggravated by a global pandemic.

In this regard, whether we are up for more 'band-aid approaches' or the much needed 'major surgery' is at least being debated. And the academy is an important context where the conversation on the 'diagnoses' not of the symptoms but rather of the origins of our society's wicked problems can foster an equitable, inclusive, respectful and democratic discussion of the ways forward by welcoming knowledges and worldviews other than those of the still dominant Western canon. And just as reconciliation "is a Canadian problem, not an Aboriginal one" (TRC head Justice Murray Sinclair, in Courchene 2019, n/a), the acknowledgement of the long held exclusion of indigenous knowledges in mainstream education and the transformations required to fix this are a collective process that should be embraced by everyone, and not exclusively dependent on the push by indigenous scholars, staff and students.

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Annex

Annex I

Research models/frameworks that emphasize ways to connect knowledge systems
(by Levac et al. 2018, pp. 5-8, adapted)

Framework	Central idea
4R-4D framework	This framework draws on Aboriginal education literature[1], including the "4Rs"[2], to develop a 4R-4D framework for understanding how narrative can be used by Elders to navigate between worldviews and embrace change. The 4Rs refer to reverence, respect, responsibility and relationality – tangible practices and obligations that cross time and space. The 4Ds refer to cultural dynamics, the cyclical and interrelated nature of existence such as those found in time, nature, story, and ancestry. The 4Rs and 4Ds are found in Umeek narratives' figures of speech. When embodied and adapted by Elders, they enable a kind of "phenomenological orienteering", or dialectical movement between past and future, and between cultural domains, creating a third space of meaning. This third space can "facilitate teaching and learning in community"[3] as well as research.
Constellations model	The constellations model sees knowledge systems as being continually evolving and forever in flux, containing shared, similar or different elements among them. Instead of viewing knowledge systems as uniquely defined, this model proposes moving away from the notion that frameworks are "containers with boundaries, and particularly away from binaries… [and towards] conversations about how to bring together multiple knowledge" systems[4].
Cultural interface	This theory prioritizes Indigenous interests without displacing other knowledge systems. It argues that the complex intersection between Indigenous and Western knowledges creates tensions that can promote change and new knowledge[5]. The theory of cultural interface prioritizes context, privileging local place-based knowledge, and sees "Indigenous knowledge as a sophisticated system rather than as a parochial limitation or obstacle"[6].
Ethical space	This concept is rooted in the opportunities for dialogue between societies that have disparate views, and is focused particularly on the ethical space between that of Indigenous and Canadian legal systems[7]. This "theatre for cross-cultural conversation in pursuit of ethically engaging diversity… [requires a focus on] language, distinct histories, knowledge traditions, values, interests, and social, economic and political realities, [and an understanding of] how these impact and influence an agreement to interact"[8].
Indigenous cultural responsiveness theory (ICRT)	This decolonizing theory was created by First Nations scholars to address Indigenous wellbeing by weaving together a variety of related concepts and frameworks including, among others, ethical space[9] and two-eyed seeing[10]. It was designed to be adapted by other Indigenous communities, organizations, and individuals. The theory "prioritizes Indigenous methodologies and ways of knowing alongside evidence-based Western practices to harmonize with localized Indigenous knowledges"[11].
Insurgent research	This methodology is built on the values of witnessing and relational responsibility; respect for, and validation of, Indigenous worldviews; and a commitment to establish research and outputs that are action-oriented, relevant and useful in Indigenous communities. It integrates knowledge systems by establishing dialogue with "both the academy and Indigenous peoples, [which forces the researcher to engage with] two distinct ways of knowing the world".[12]
Expansive learning	This pedagogy, coming from environmental studies and development work, uses a multi-voice approach to bridge the gap between different knowledge systems[13]. It aims to "create space for interaction and negotiations among a diverse group of stakeholders and actors…[to reveal] the connection between action and meaning among the relevant stakeholders in a given context or situation…[and to make] "the various actors aware of and conscious about their local heritage [and] environmental knowledge"[14]. It sees conflict and contradictions among divergent knowledge systems as essential for learning.
Hybridity	Hybridity is a concept that employs principles from both intersectionality and queer studies, providing an alternative way to understand "social positions within complex and intersecting systems of power"[15]. It complicates rigid sex and gender categories such as male, female, homosexual and heterosexual.

Indigenous métissage	This "decolonizing research sensibility"[16], is "inspired by Plains Cree and Blackfoot philosophical insights that emphasize contextualized and place-based ecological interpretations of ethical relationality"[17]. This approach uses interpretations of tangible artifacts to channel multiple understandings of place, culture, and identity. In this way, "Indigenous Metissage purposefully juxtaposes layered understandings and interpretations of places in Canada with the specific intent of holding differing interpretations in tension without the need to resolve or assimilate them. The goal is to resist colonial frontier logics and instead forward new understandings of the relationships connecting Aboriginals and Canadians"[18].
Möbius strip metaphor	The Mobius Strip is a rectangle with one end twisted 180 degrees to join the other end, thus forming an infinite loop, which turns back towards its starting place. The metaphor of the Mobius Strip encourages "reflection on how the seemingly two sides [or two ways of knowing] co-create each other…[and provides] a pathway for moving together"[19] through shared experiences and knowledge, while respecting and acknowledging differences.
Polycentric global epistemology	This theory is fundamentally interested in Indigenous self-determination. It encompasses ideas from scholars whose work is considered "post-Eurocentric, postcolonial, post-Enlightenment, global, multicultural, feminist, polycentric, pluricentric, transmodern, [and] emancipatory"[20]. It seeks to balance the power inherent in knowledge systems by decentering truth, acknowledging that there are multiple ways of knowing, and privileging historically excluded voices.
Rhizome	This model "provides a space for thinking about research-creation practices happening on the periphery of Indigenous and Western paradigms"[21]. New knowledge is co-created within an open, non-linear space and results in knowledge that is "more robust, more accountable, more usable; knowledge that 'serves locally' at a given time"[22].
Three sisters framework	The Three Sisters is a Haudenosaune creation story[23] using a metaphor to bring together multiple ways of knowing that might support and complement each other. It rejects the idea of a single, universal truth. "The Three Sisters [corn, beans, and squash] offer us a new metaphor for an emerging relationship between Indigenous knowledge and Western science…. I think of the corn as Traditional Ecological Knowledge, the physical and spiritual framework that can guide the curious bean of science, which twines like a double helix. The squash creates the ethical habitat for coexistence and mutual flourishing. I envision a time when the intellectual monoculture of science will be replaced with a polyculture of complementary knowledges. And so all may be fed"[24].
Transrational knowing	This methodology creates a bridge from dominant Western forms of knowledge "to appreciating and understanding important aspects of Indigenous ways of coming to know"[25]. It recognizes methods that may include non-linguistic forms of communication such as "dreams, intuitions and interspecies communication… [as well as] agency in both material and non-material worlds"[26].
Etuapmunk, or Two-eyed seeing	Mi'kmaq Elder Albert Marshall has developed this metaphor for negotiating between two cultures[27]. It requires "learning to see from one eye with the strengths of Indigenous knowledges and ways of knowing, and from the other eye with the strengths of Western knowledges and ways of knowing, and to use both these eyes together, for the benefit of all"[28]. Common ground is pursued between the "different scientific knowledges"[29] of Indigenous and Western science within a co-learning, active and inclusive environment.
Guswentah, or Two-row wampum	This is a metaphor that emphasizes the value of space for each system to enhance the other[30]. The Two-Row Wampum was a friendship treaty between the Dutch and the Haudenosaunee and "the rows of beads on the belt represent Dutch vessels and Iroquois canoes, traveling side by side down 'the river of life'"[31] without interfering in each other's wellbeing.
Working the hyphen	This theory sees the hyphen "as a marker, which indicates a relationship between collaborating peoples as well as their respective relationship to difference…"[32]. This relationship is formed when "the researcher (the Self) and the researched (the Other) are joined"[33].
Kaupapa Ma—ori	Kaupapa Ma¯ori is a methodological framework that combines Western critical theory and Ma¯ori ways of knowing, which include "an inseparable relationship between the world of matter and spirit"[34]. It is a form of resistance and agency[35]. The framework uses the principles of "whakapapa (relationships), mana (justice and equity), tika (research design) and manaakitanga (cultural and social responsibility)"[36] to organize ethical practices across the Maori community[37].

Living on the ground	This methodology is rooted in both feminist and Indigenous knowledges. It requires learning through the senses and letting go of previous notions of learning through intellect, a move that requires use of the whole body "as a vehicle for my learning – my physical, intellectual and spiritual body. I learnt to dream and to feel and believe in the Tjukurrpa [Dreaming]. Living on the Ground with the women Elders enabled me to experience the women's world: not in place of them, but with them"[38].

References as compiled by Levac et al. (2018). For full sources refer to the referenced publication.

1 Specifically, the concepts of "metaphoric blending" (Fauconnier, 1997), "integrative complexity" (Turner &
Fauconnier, 1999) and "skilled phenomenological orienteering" (Alverson, 1991)
2Archibald (2008); Kirkness & Barnhardt 1991
3 Atleo, 2012, p. 3; Also see Atleo 2001
4 Evering, 2012, p. 366
5 Nakata, 2002, p. 285
6 Yunkaporta, 2009, p. 53
7 Ermine, 2007
8 Ermine, 2007, p. 202
9 Ermine, 2007
10 Bartlett et al., 2012
11 Sasakamoose et al., 2017, p. 2
12 Gaudry, 2011; Gaudry, 2011, p. 128
13 Carm, 2014
14 Carm, 2014, p. 74
15 Fotopoulou, 2012, p. 28
16 Donald, 2012, p. 533
17 Donald, 2012, p. 536
18 Donald, 2012, p. 542
19 Fornssler, personal communication, June 6, 2017
20 Maffie, 2009, p. 60
21 Fornssler et al., 2014, p. 190
22 Meyer, 2010, p. 123
23 Wabano Centre for Aboriginal Health, 2014
24 Roots of Wisdom Project Team, 2016, p. 8
25 Barrett, 2013, p. 180
26 Barrett, 2013, p. 188-189
27 McKeon, 2012, p. 136
28 Bartlett et al., 2012, p. 335
29 Hatcher et al., 2009, p. 147
30 Johnson et al., 2016
31 Johnson et al., 2016, p. 28
32 Webster & John, 2010, p. 189
33 Wagle & Cantaffa, 2008, p. 136
34 Murton, 2012, p. 91
35 Bishop, 1998; Tuhiwai Smith, 1999
36 Came, 2013, p. 65
37 Tuhiwai Smith, 2000, p. 230
38 de Ishtar, 2005, p. 363

Annex II

Principles and methods that involve learning from multiple knowledge systems

Summary of guiding principles found in the linking frameworks and in intersectionality (by Levac et al. 2018, pp. 11-12, adapted)

Principle	Essential commitment
Relationality	**All of creation is interdependent and interconnected in complex and sometimes antagonistic ways.** Relationships between Nations, people, and human and nonhuman entities, crystallize the interconnections inherent in the world. Building relationships is time-consuming but essential for creating solidarity. Relationality is core to intersectionality's way of thinking about how groups of people relate to one another and to social and political structures, but this relationality does not extend beyond human relations.
Reciprocity	**We must value and engage with ways of knowing other than our own on an equal basis of exchange.** Reciprocity signals a commitment to giving all knowledge systems equal consideration, and is seen as a requirement for ensuring "mutual protection, benefit, and continuity." Within intersectionality, Reciprocity focuses more on giving equal consideration to marginalized peoples' experiences within the research process, but similarly makes a commitment to mutual benefit.
Reflexivity	**Researchers must continuously examine their positions within existing power relations.** Being reflexive involves respecting difference and understanding one's own position in existing power structures. Reflexivity can happen individually, interpersonally, and collectively. Reflexivity is considered central to intersectionality's critique of power. It includes examining power relations at the micro and macro level, and also across space and time. In both linking frameworks and intersectionality, Reflexivity allows us to interrogate what we "know," how we know, and which questions are important to ask.
Respect	**Research designed and directed by collaborators helps to ensure that the research is respectful of difference.** Respect is an essential principle for ensuring autonomy and self-determination. Respect is tightly connected to the principle of Relationality to ensure that relevant and useful research takes place. Respect implies that research be guided by communities, though in some instances, such as in Inuit communities, "ownership" is less favourable than "sharing," which requires flexibility in how Respect is operationalized. Also as with Relationality, Respect in linking frameworks includes attention to human and non-human entities. In intersectionality, Respect requires taking great care to avoid the exploitation of people who have been marginalized, and to avoid essentializing people. Respect in intersectionality also includes attending to the relationship between privilege and oppression and avoiding practices that perpetuate both.
Reverence	**Research should be informed by spiritual values and practices.** Reverence is owed to the metaphysical plane as an important site of knowledge that is accessed through traditional ceremonial practices. Intersectional scholarship does not hold Reverence as a principle, but does make some reference to how oppression can destroy one's spirit. This suggests at least some acknowledgement of the metaphysical realm.
Responsivity	**Knowledge systems are fluid and responsive to change.** The principle of Responsivity refers to the process of adaptation necessary for learning from across cultures and histories, a process which is ongoing in most cultures. In intersectional thought, this principle resonates with a focus on connecting dominant and subjugated knowledge systems.
Responsibility	**Research should further social justice and holistic wellbeing.** Responsibility is the principle that calls for research to contribute to "recovery, healing, and development," and to consider the impact of research on the planet and on future generations. In intersectionality, the principle of Responsibility is tied to a commitment to social justice, and thus the need to think about resistance and resilience. Again here, an important distinction is that intersectional scholars do not necessarily extend their commitments to justice beyond the human world.

Methods that can support the seven principles
(by Levac et al. 2018, pp. 13-14, adapted)

Method and key principles	Description and considerations
Storytelling	Jo-Ann Archibald's work on the pedagogical value of intergenerational oral storytelling is widely recognized. It "builds on the seven principles of respect, responsibility, reciprocity, reverence, holism, interrelatedness, and synergy that form a framework for understanding the characteristics of stories, appreciating the process of storytelling, establishing a receptive learning context, and engaging in holistic meaning-making"[39]. Oral narratives are often image-based and reflect the complex and textured nature of Indigenous ways of knowing[40].
Yarning	Yarning is considered by some to be a subtype of storytelling; one research team[41] describes it as an Australian Indigenous method that uses an informal and relaxed conversational process to share stories, develop knowledge and build accountable relationships to the community[42]. It prioritizes Indigenous ways of communicating, "in that it is culturally prescribed, cooperative, and respectful"[43].
Sharing circles and talking circles	Sharing circles and talking circles are group-based conversational approaches to gathering data. They share some characteristics with focus groups. The talking circle is a tribal method of group information sharing and discussion, with a focus on cooperation within the group. A talisman is often used to denote the speaker at any given time[44]. In a sharing circle, participants are similarly gathered together to discuss the research topic in a way that promotes "sharing all aspects of the individual—heart, mind, body, and spirit"[45].
Marae wānanga (w/ Whakawhiti korero)	Marae wānanga are meetings in traditional meeting houses wherein the researcher is positioned as a guest, and the format promotes cultural safety by, for instance, embedding ceremony in the data collection[46]. This type of research is often used with individuals who have experienced trauma. A method drawn from Maori daily life - Whakawhiti korero (i.e. the exchange of ideas and discussion) is used within a Marae wānanga session[47].
Halaqah	Halaqah is a traditional Islamic pedagogy, which Ahmed has adapted as a narrative inquiry method of research. Ahmed claims that this method positions participants as co-constructors of knowledge, celebrates the "sacred, spiritual and transformative nature of ilm (knowledge) and values the beliefs, cultural aspirations and collective autonomy of Muslims"[48].
Arts-based research methods	Arts-based research methods use elements of the creative arts in order to better understand the significance of an object of study within a particular culture. These methods are considered to be participatory because they "directly involve the participants of the research in a practical and real way"[49]. Some arts-based methods include quilting, photo interviewing, photovoice, reflexive photography and Anishnaabe symbol-based reflection (an adaptation of photovoice). Within Hawaiian culture, quilting has been used historically as an (often private) expression of resistance to Western dominance and ways of knowing, and thus provides symbols of loyalty to Indigenous identity and community[50]. Photo interviewing (and associated techniques) is a widely used Western research method that originated in the mid to late 1970s[51]. It can include using participant-supplied photos or videos as data (reflexive photography), examining participants' responses to photos or video (photo interviewing), and encouraging participants to express their community through photos (photovoice)[52]. Anishnaabe symbol-based reflection shares some characteristics with photovoice, but instead of photos, uses paintings, drawings, sculptures, crafts, songs, teachings, or stories[53].
Critical ethnography and auto ethnography	In critical ethnography, research methods such as participant observation focus on language and acts within everyday life. Facts and truth are understood through their wide acceptance within a group or culture[54]. This requires collaboration throughout the research process. Auto ethnography draws on the researcher's own experience to understand a phenomenon[55].
Hermeneutics	Hermeneutic inquiry is an interpretative research method that seeks to understand meaning within context[56]. A researcher engaged in hermeneutics "[interprets] a relationship between memory, time, place and the text" they are studying, and understands a text or oral story as dynamic, meaning that the "energies of the Earth" and of humans are ever-changing[57].

Collective consensual data analytical procedure (CCDAP)	The CCDAP is a team-based data analysis technique to identify overarching themes within findings. It involves a process of visually representing and collectively organizing data[58]. CCDAP seeks out multiple ways of knowing through collaboration and consensus, thus prioritizing principles of reciprocity, responsivity, and respect.
Inclusion of wisdom keepers (e.g., Elders)	Within Indigenous communities, Elders are considered wisdom keepers and learning from them is considered by many to be an essential method of research. A key informant offered the following insight into the importance of Elders' knowledge: "The thing that's helped the most… is the time I've spent with Elders, which hasn't been near enough… It does me more good than pretty much anything else… That embodied part is…really important and is also the most difficult part to explain but until you embody it you haven't actually taken it up…"[59].
Pagtatanungtanong	*Pagtatanung-tanong* is a Filipino word that means asking questions. This interview method, is rooted in Indigenous Filipino culture, is adaptive to contextual norms, and is used in conjunction with other Indigenous research methods. Primarily, it addresses power imbalances between researchers and informants because both are and afforded equal status, decision making power, and time to ask questions of the other[60].
Talanoa and Faafeletui	Talanoa and Faafaletui describe two research methods that "claim meaning and significance from a common Indigenous Pacific, particularly Polynesian, worldview [and that use metaphors] to describe a process of storying and gathering narratives"[61]. Talanoa describes a process of coming together, of creating a collective discussion, and Faafaletui is the process of weaving together knowledges.

References as compiled by Levac et al. 2018. For full sources refer to the referenced publication.

[39] Archibald, 2008
[40] Dyll-Myklebust, 2014
[41] Geia et al., 2013
[42] Geia et al., 2013; Walker et al., 2014; Yunkaporta 2009; Aveling 2013
[43] Walker et al., 2014, p. 1216
[44] Haozous et al., 2010
[45] Lavellee, 2009
[46] Elder, 2013
[47] Elder & Kersten, 2015
[48] Ahmed, 2014
[49] Lavallee, 2009, p. 30
[50] Kaomea, 2016
[51] Castleden, Garvin, & Huu-ay-aht First Nation, 2008; Hurworth, 2003
[52] Hurworth, 2003, p. 3
[53] Lavallee, 2009
[54] Webster & John, 2010
[55] White, 2010; Yunkaporta, 2009
[56] Donald, 2012
[57] Kulnieks et al., 2010, pp. 16-17
[58] Bartlett et al., 2007
[59] Dr. Tricia Marck, personal communication May 26, 2017.
[60] Church & Katigbak, 2002; Pe-Pua, 1989
[61] Suaalii-Sauni & Fulu-Aiolupotea, 2014, p. 334

Annex III

(Intended) survey template directed at environmental science graduating students and alumni of selected university program(s) inclusive of IK/TEK perspectives

Indigenous knowledge in higher education

Dear graduate/student,

My name is Priscilla Santos and I am a MSc student in Environmental Sciences, Policy and Management (MESPOM) at the Central European University (CEU), Budapest.

I am currently working on my thesis research project with a focus on Indigenous knowledge/traditional ecological knowledge (IK/TEK) in the university context. More specifically, the major aim of my research is to shed light on the role of environmental science programs that are inclusive of IK/TEK perspective in contributing to sustainability solutions.

Because you either graduated from - or are about to finish your studies at - a selected environmental science program inclusive of IK/TEK perspectives, you are now invited to take part in an anonymous online survey consisting of multiple choice and open-ended questions.

Participation is voluntary, and you are free to withdraw at any time. If you decide to collaborate, you will need to provide an email address when answering the survey. I will attribute an individual and unique respondent identification code to this email, and the key to the code is used exclusively by me. In case you need to contact me regarding your responses, the email address provided is needed so that I can trace back your specific answers. This is important in case you change your mind and you no longer want your answers to be included in the analysis. If this is the case, your request should be sent to me via email at xxx@xxx no later than MM DD, YYYY.

This survey is available until MM DD, YYYY. It is expected to take approximately 15 minutes to be completed, and you are kindly requested to answer the survey only once. Your answers will be handled confidentially. Please do not hesitate to email me at xxx@xxx if you have any questions or concerns!

Thank you for your time and attention, your collaboration is much appreciated!

* Required

1. Email address *

2. Have you finished the program? *

Mark only one oval.

- ◯ Yes *Skip to question 3*
- ◯ No *Skip to question 5*

Alumni information

3. When did you complete your studies? (YYYY) *

_____

4. Please provide a brief description of your activities after graduation (e.g. job title and/or main tasks/responsibilities). *

_____

_____

_____

_____

_____

Skip to question 6

Current students' information

5. When is your expected graduation? (YYYY) *

_____

Sustainability solutions and Areas of practical significance for traditional ecological knowledge as common heritage of the humankind

Biological information & ecological insights, resource management, conservation of protected areas, biodiversity conservation, environmental monitoring & assessment, development, dealing with disaster & extreme weather events, and environmental ethics. Berkes (2018) highlights these 8 areas as important fields where the complementarity of Indigenous knowledge/traditional ecological knowledge and scientific knowledge implies great potential for contributions to solving the current social-ecological crisis through sustainabilty solutions. For example, in the area of resource management, the prediction of potential resource collapse (e.g. fish stocks), and thus the avoidance of such collapse, is among sustainability solutions that could benefit from the knowledge of traditional resource extractors (e.g. local fishers) combined with scientific data, thus contributing to knowledge on the resource.

In this context, there is room for a better understanding of how considerations on IK/TEK perspectives in environmental science programs influence sustainability solutions.

You are now invited to select at least 2 of those areas to elaborate briefly on sustainability solutions associated with them considering your experience as an environmental science student. Next, you can elaborate on whether and how these sustainability solutionsrelate to your current activity/job/position (for alumni).

6. Please select at least 2 of the following areas of practical significance for traditional ecological knowledge as common heritage of the humankind. These areas should then be associated with sustainability solutions considering your experience as an environmental science student. You are invited to elaborate on these solution in the text-boxes provided. If you think that you can associate sustainability solutions to more than 2 of these areas, you can further elaborate on as many areas as you want - but keeping in mind these solutions should take into consideration your experience as a student in the specified program! *

Check all that apply.

- [ ] Biological information and ecological insights
- [ ] Resource management
- [ ] Conservation of protected areas
- [ ] Biodiversity conservation (stewardship of biodiversity)
- [ ] Environmental monitoring and assessment
- [ ] Development
- [ ] Dealing with disasters and modern crises
- [ ] Environmental ethics

7. What sustainability solutions are influenced by considerations on IK/TEK perspectives for selected Area 1 considering your experience as an environmental science student? (Please identify the area!) *

8. How these solutions for selected Area 1 are influenced by considerations on IK/TEK perspectives? *

9. What sustainability solutions are influenced by considerations on IK/TEK perspectives for selected Area 2 considering your experience as an environmental science student? (Please identify the area!) *

10. How these solutions for selected Area 2 are influenced by considerations on IK/TEK perspectives? *

11. What sustainability solutions are influenced by considerations on IK/TEK perspectives for selected Area 3 considering your experience as an environmental science student? (Please identify the area!) How these solutions are influenced by considerations on IK/TEK perspectives?

12. What sustainability solutions are influenced by considerations on IK/TEK perspectives for selected Area 4 considering your experience as an environmental science student? (Please identify the area!) How these solutions are influenced by considerations on IK/TEK perspectives?

* Up to question 16, the pattern of questions was maintained – i.e. the question on sustainability solutions in a given area (up to area 8), and how consideration of IK/TEK perspectives influence them.

17. For alumni: Are sustainability solutions part of your current job/position/activities? (Current students, please select N/A) *

Mark only one oval.

- Yes *Skip to question 18*
- No *Skip to question 20*
- N/A *Skip to question 21*

Sustainability solutions in current activities

18. What sustainability solutions are part of your current job/position/activities? *

19. Are these solutions influenced by considerations on IK/TEK perspectives that were present in the environmental science program you attended? If yes, how?

Skip to question 20

The value of IK/TEK perspectives to current activities

20. How would you describe the value of considerations on IK/TEK perspectives to your job/position/activities after graduation? *

Caution on assuming IK/TEK as the 'silver bullet' to sustainability solutions

Nakata (2002) contends that "the intersections of different knowledges... produce tensions and condition what is possible but do not directly produce certainty of outcomes".

With that in mind, and considering the interplay between scientific knowledge and IK/TEK present in the environmental science program you attended, you are now invited to briefly elaborate on limitations, weaknesses/risks, and strengths/opportunities associated with considerations on IK/TEK perspectives in environmental science programs influencing sustainability solutions.

21. What limitations are associated with considerations on IK/TEK perspectives in environmental science programs influencing sustainability solutions? *

22. What weaknesses/risks are associated with considerations on IK/TEK perspectives in environmental science programs influencing sustainability solutions? *

23. What strengths/opportunities are associated with considerations on IK/TEK perspectives in environmental science programs influencing sustainability solutions? *

Skip to question 24

'Glocality' and global vs. local sustainability solutions

One of the main features of IK/TEK is its 'locality' aspect. However, not only similar ecological adaptations can be observed when contrasting Indigenous peoples' practices in comparable contexts but also functional equivalents can be found in distinct geographical and cultural contexts. Therefore, IK/TEK goes beyond local significance - as well as sustainability solutions associated with it. This echoes the concept of 'glocality'.

24. In light of considerations on IK/TEK perspectives present in the environmental science program you attended, what relationship would you attribute to local vs. global sustainability solutions? *

25. Would you be willing to be interviewed via phone/Skype if further questions emerge and/or clarification is needed? *

Mark only one oval.

- ◯ Yes *Skip to question 26*
- ◯ No *Skip to question 27*

Contact details

26. Please provide your contact information (email and/or phone number and/or skype ID). *

27. Any final comments or suggestions?

Annex IV

Illustrative interview guide

Opening: brief personal introduction & ethical considerations

Interview

If recording: say out loud date and time. **If anonymity required, identification as the role** (e.g. indigenous knowledge academic/practitioner)**. If no-anonymity required, identification as the name**.

Guiding interview question: How consideration of IK/TEK perspectives in environmental science programs influence sustainability solutions?

Question 1: Brief interviewee introduction (warm-up)

Question 2: 'What?' and 'why?'

2.1 Do you think that considerations of IK/TEK perspectives in environmental science programs influence sustainability solutions?

> Potential request for clarification from the interviewee: **what do you mean by 'sustainability solutions'?** Answer: By sustainability solutions I mean initiatives, policies or actions in a particular area that are meant to advance environmental sustainability. Focusing on "IK/TEK perspectives", and the "experience" aspect of it, I'm mostly interested in practical significance. For example, in the area of resource management, engagement with traditional knowledge to fill data gaps and contribute to knowledge on the recourse and avoidance of depletion.

- **If yes**: What sustainability solutions would you say that are influenced by IK perspectives in environmental science programs?

  - Why is this influence there?

- **If no**: Why not?

  - In what scenario do you think that such influence would happen, and how? (If there is room, be inclusive of *teaching*, *research*, and *outreach* concepts)

The following questions apply to an "yes" answer to question 2.1 only

Question 3: Further exploring 'How?'

3.1 If 'yes' in previous answer: How then sustainability solutions are influenced by considerations of IK/TEK perspectives in environmental science programs?

- Can you elaborate briefly on the role of teaching in influencing sustainability solutions, and how the difference between *teaching IK* and *teaching about IK* reflect in sustainability solutions?

- Can you elaborate briefly on the role of research in influencing sustainability solutions?

- Can you elaborate briefly on the role of outreach in influencing sustainability solutions?

Question 4: Examples

4.1 Are there any examples, in your experience, of sustainability outcomes that were influenced by consideration of IK/TEK perspectives in environmental science programs? If yes, can you briefly describe them (e.g. what is/are the sustainability outcome(s) and how were they influenced)?

Question 5: Local? Global? Glocal?

The 'glocality' concept (think global, act local) can be associated with sustainability solutions influenced by indigenous knowledge not only because similar indigenous practices are found in similar contexts, but different practices that fulfill the same function are found in different contexts.

5.1 How would you say that consideration of IK/TEK perspectives present in environmental science programs reflect the 'glocality' concept thinking about sustainability solutions?

- How do you go about it in the <specific program>? Is there a conversation about local vs. global implications of activities in general?

The following questions apply to "yes" and "no" answers to question 2.1 (but require wording adjustment for "no")

Question 6: SWOT

- (if "no" to question 2.1, start with "What are the main…" instead of "Are there any…")

6.1 Are there any *limitations* that you attribute to considerations on IK/TEK perspectives in environmental science programs influencing sustainability solutions? If yes, what are they? If no, why not?

6.2 Are there any *weaknesses/risks* that you attribute to considerations on IK/TEK perspectives in environmental science programs influencing sustainability solutions? If yes, what are they? If no, why not?

6.3 Are there any *strengths/opportunities* that you attribute to considerations on IK/TEK perspectives in environmental science programs influencing sustainability solutions? If yes, what are they? If no, why not?

Question 7: Closing

7.1 Is there any point that you consider important for me to consider that I have missed? (potential follow-up in terms of suggested references)

7.2 Any final comments, suggestions, close-up statement…?

Annex V

Example of a final assignment submitted for the IESS course 'Introduction to Indigenous Environmental Studies', in the form of a poem, retrieved from IES (2018, p. 41).

If there is a constant

IESS student Olivia Mater

why am I here?

i ask this to the space around me
the cedars
the sky
the glowing sun
the singing birds
the river

why am I here?

as I sit by the river
i feel my heart beating
an echo of the rhythm of her rapids
i watch as the cool ebb and flow of her waters
dance over rock
weaving around meanders
carving out her path home

and it is here that I feel most alive.
by the water I breathe again
in her rushing current lies power
and compassion
forces of strength and humility
coursing
pulsing
breathing life into this world

this is her gift
a profound act of love.

water has shown me that in this life
I will sink low
to the dark silence of deep blue
and I will rise
like waves
like the tide
to see the sun again.

I will be pulled by the moon
and shaped by winds of change
I will hold rage like rapids in spring
and calm
like the stillness of a lake
on a starlit night.

nothing in this life will ever be static
but if there is a constant
let it be love.

as I move through this world, i want to reflect a rivers' capacity to love. to carry life forward, create space
hold up hearts and
bolster the momentum of change.

As Dan says
"We are here for a limited amount of time.
a certain number of breaths.
what will you do while you are here?
how will you work for the continuation of all life?
find your purpose."

As a settler
i feel an inherent responsibility
to form a deep understanding of the space I occupy
the space I take away
and the space I am willing to give up.
My ancestors did enough
said enough
took enough
that's
enough.
It is my job to forge a path towards a different story.
to stop the degradation
the destruction
the depletion
extraction
and violent theft of the legacy they left
and use everything I have
to work towards the restoration
revitalization
and
strengthening
of land
water
beings
hearts
bodies
pirits.
i see a new path
and it's going to take a force of unrelenting love to get us there.

it's going to take the building capacity
of relationship
and deep understanding
of accountability reciprocity and balance

I am an offering and a taking
a gift and a weight
i am strength and I am permeable.

I am words
I am song
I am a painting
I am vision
I am laughter
I am hands outstretched

Here
take this
i call it love.

For a final assignment for IESS 2601Y :
https://www.youtube.com/watch?v=1fWSAS0Rnj4