ENRICHING SCIENCE EDUCATION THROUGH INDIGENOUS KNOWLEDGE:

Epistemological Reflection in Intercultural Dialogue

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The challenge of science education includes the decontextualization of knowledge, the lack of connection with the reality of students, the difficulty of students in transferring their learning to new situations, and their demotivation or disinterest in issues and scientific careers. This situation is mainly due to the gap between the daily culture of young people and scientific culture, a phenomenon amplified in an Indigenous environment (Aikenhead & Elliott, 2010).

After half a century of claims and studies promoting the introduction of First Peoples' knowledge into school, the discourses and pedagogical practices in sciences differ widely from one class and province to another. According to the five-stage scale of inclusion of Indigenous knowledge in the Afonso Nhalevilo (2013, cited in Eun-Ji Amy Kim, 2015) school system, Quebec, for example, is at the level of "colonialism", with Indigenous content representing 0.12% of the science curriculum[1]. At the other end of the spectrum, Saskatchewan views Indigenous knowledge as "a way of knowledge in parity with the sciences of life, physical sciences and earth and space sciences, and the cultural perspective is considered as a ''learning context", at the same level as scientific inquiry, technological problem solving and decision-making in science, technology, society and the environment" (Eun-Ji Amy Kim, 2012). These pioneers, who integrate Indigenous ontology, axiology and epistemology into the school system, inspire me.

Drawing on my personal and professional experiences in a bicultural environment[2], I will attempt here, after having characterized the issue of science learning, to show how the inclusion of Indigenous educational and socio-ecological cultures can address several challenges inherent to this field of education, while giving it added value.

Cleavage between Indigenous youth and scientific culture

In the first part of the article, we will examine the roots underlying the failure of scientific education for most people by describing the three dimensions of the cleavage between Indigenous youth's daily culture and scientific culture: that of language, that of concept representation, and that of the mode of understanding[3].

The first difficulty is the differences between scientific language and everyday language. Indeed, certain words, such as "energy" or "work" in physics and "character" in biology, have different meanings in everyday life. Other words are completely unusual like "ion" or "phenotype" and must be integrated quickly to understand the phenomena studied. In a second language, comprehension and retention of vocabulary are all the more demanding on a cognitive level.

The representation of concepts is, for its part, accentuated by cultural differences for ontological or axiological reasons. For instance, from elementary school onwards, students are challenged with six Atikamekw seasons (with respect to activities on the territory[4]) as opposed to four occidental seasons (linked to solstices). In this case, the two ways to conceive seasons are complementary. However, the definition of "living" can lead to a conceptual conflict: whereas in sciences, reproductive capacity is one of the criteria for considering a "living" organism, certain stones are considered "living" by the Atikamekw, as also are the mountains or Mother Earth (*nitcotco aski*[5]). The representation of the forest also differs widely from one group or person to another: a biologist sees it as a pattern of interrelationships between several species, a forest industry worker, an economic value, a hunter, bears and moose, a grandmother, blueberries at the end of the summer, and adventurers, wellness or personal development. *Notcimik,* a term used by the Atikamekw referring to the forest, means "the place where one comes from", and the images associated with it have a strong historical, social, identitarian, dietary, utilitarian, educational, medicinal and spiritual impact, as described by Saint-Arnaud (2009) for the Anicinabek.

The epistemological gap that exists between the intuitive way of learning the everyday life of students and the structured approach to acquiring knowledge in science is the third major challenge to overcome in teaching. One of the pedagogical strategies is to create cognitive conflicts, their resolution leading to the transformation of students' initial beliefs and the integration of new ways of conceiving phenomena. However, this approach can affect self-esteem and engender a negative attitude towards school, even anxiety, as well as a rejection of a way of thinking, strongly related to identity (Scott, Asoko, & Driver, 1991). Biculturalism is then called "subtractive", that is, it removes value from the initial situation; it is part of a posture of cognitive imperialism, inherited from colonization. Indeed, the confrontational characteristic of the cognitive conflict approach, coupled with a dualist world view, is inconsistent with Algonquian educational cultures, which are holistic and non-interventionist. Another common practice in science education is laboratory experimentation, resulting from positivist epistemology that denies or attempts to eliminate possible interactions between the "researcher" and his subject. In the classroom, planning for observation, analysis, hypothesis formulation or outcome prediction generally leaves little room for initiative and holistic experience. This dirigiste approach can be limiting for students whose predominant type of intelligence is naturalist-ecologist[6], numerous in Indigenous communities, who are nonetheless good observers.

Anchoring learning in the local socio-ecological dynamics, promotes young people's commitment while having an impact beyond the school setting. For example, genetic exercises related to crossbreeding can feed discussions about genealogy and racism, two important social issues in community and intercultural relations.

Taking advantage of biculturalism in science education

While the bicultural context of Indigenous communities creates challenges for the acquisition or construction of scientific knowledge, it also offers valuable resources to reduce language, conceptual and pedagogical problems. In this second part, we will describe them using the Indigenous learning characteristics: collective, intergenerational, rooted in the socio-ecological environment and the holistic, experiential and personalized languages.

Typical of collectivist societies, the communication technique of the speaking circle can become the learning community's centre of life. Based on principles of listening and free expression, it promotes empathy, awareness, sense of belonging, self-affirmation, knowledge sharing. The

associated mode of communication encourages to talk about oneself, which avoids confrontation, and allows the personalization of learning. The expression in the form of life narratives leads to the contextualization of learning and develops systemic and holistic thinking, including the intellectual, emotional, physical and even spiritual dimensions of the experiences told. Practised at the end of the learning cycle, it is conducive to metacognition, reflexivity, critical and holistic thinking (Lathoud, 2016).

At the other end of the spectrum, Saskatchewan views Indigenous knowledge as "a way of knowledge in parity with the sciences of life, physical sciences and earth and space sciences, and the cultural perspective is considered as a "learning context", at the same level as scientific inquiry, technological problem solving and decision-making in science, technology, society and the environment" (Eun-Ji Amy Kim, 2012). These pioneers, who integrate Indigenous ontology, axiology and epistemology into the school system, inspire me.

The intergenerational character of traditional Indigenous learning could be introduced in school by inviting the members of the community to share their knowledge related to the environment, such as chiefs of territories or wildlife officers, to enrich theoretical knowledge. Elders and their system of local socio-ecological knowledge, their language intrinsically linked to the territory as well as their mode of transmission and acquisition of knowledge (stories of life, stories, legends, songs, prayers, dreams[7], ceremonies) can be an asset in science education.

Language, the gateway to worldviews, is another pillar of Indigenous education. Contrary to the trend of exclusive use of the language of instruction, it may be relevant to encourage young people to translate the concepts studied (Mady and Garbati, 2014). In fact, some notions, new in sciences, are very ancient for Indigenous people. Biomimicry, for example, nowadays inspires high technology, whereas it has been practised since the beginning of times by Indigenous people, who consider animals in particular as teachers. The concept of ecosociosystem, now placing the human being within the ecosystem, is also closer to the indigenous representation of human-territorial relations. In biology, the comparison of biotic/abiotic scientific categorization[8] and animate/inanimate indigenous categorization is another fine subject of intercultural dialogue. Certain representations remain however incomparable. Indeed, it is difficult to compare the theories of evolution with legends such as that of creation, which tells us that humans were transformed into animals to save the humanity, whereas there was only sand on earth. To avoid the harmful effects of cognitive conflict, harmonious cohabitation between indigenous and academic cultures can be achieved through "double vision" (Etuaptmumk in Mi'kmaq)[9]. It allows us to consider, from one perspective, Indigenous knowledge and learning styles and, from the other, their Euro-Canadian counterparts to use both perspectives for the benefit of all. This attitude, which corresponds to the highest level of the collateral learning spectrum of Aikenhead and Jegede (1999), is, moreover, adopted by researchers who are influenced by parallel ways of thinking and who have beliefs that are sometimes inconsistent with their scientific rationality. (Morin, 1986).

Anchoring learning in the local socio-ecological dynamics, another unavoidable part of Indigenous education, promotes young people's commitment while having an impact beyond the school setting. For example, genetic exercises related to crossbreeding can feed discussions about genealogy and racism, two important social issues in community and intercultural relations. The proximity of the territory and contemporary infrastructure of health, water treatment, waste or exploitation (mining, hydroelectricity, deforestation) allow an experiential learning–the suggested observation being rather of participative type. Access to traditional food or medicine preparation practises is enriching for science education, since it also adds an interdisciplinary and holistic perspective. In the study of animal systems and functions, for example, dissections can be supplemented with vocabulary in the Indigenous language, medicinal properties, knowledge of the relationships between species, their climate-related habits, symbolic representations, and rituals, life narratives of the elders and legends. In chemistry, preceding the aspirin[10] synthesis experiment with the traditional production of a willow decoction, from harvesting to medicinal application, allows students to become familiar with chemistry vocabulary and practice (boiling, extraction, filtration, solution, mixing, separation) while acquiring ancestral knowledge.

Thus, in addition to reducing the language, conceptual and pedagogical barriers of science education, the introduction of indigenous epistemological elements allows the development of systemic, holistic, reflective thinking rooted in the socio-ecological reality of young people, in addition to increasing the sense of belonging to the community and to the territory and to enable the acquisition of certain skills in intercultural dialogue. This could inspire teachers struggling with a curriculum that some might consider a relic of colonization, like Alice Keewatin (2002) who refused to teach in an Indigenous community, saying that it would contribute more to the problem than to its solution. ■

NOTES

1 Secondary Cycle 1.

2 I have created and led several educational projects on Atikamekw and Inuit territories, some as part of doctoral research in environmental education. I spent three years on the ancestral territory with an Atikamekw elder from Manawan.

3 These are combined with limitations in financial, material, human, educational and social resources and dynamics involving historically documented intergenerational traumas.

4 *Sikon* pre-spring; *Miroskamin* : spring; *Nipin* : summer; *Takwakin* : fall; *Pitci-pipon* : pre-winter; *Pipon* : winter.

5 My Mother-Earth.

6 Nine types of intelligence have been documented by Gardner (1999): visual/spatial, corporal/kinesthetic, musico-rhythmic, naturalist-ecologist, verbo-linguistic, logico-mathematical, interpersonal, intrapersonal and existential.

7 For the "scientific method" followers who might be reluctant to open up to a "spiritual" dimension of learning, let us recall that it was after his dream of the snake biting its tail that the chemist Kékulé discovered the cyclic formula of the benzene molecule.

8 Living/nonliving: some scientific categories are debatable. Are viruses alive if they depend on other organisms to reproduce? Algae, which photosynthesize, are they plants? Are red blood cells cells when they have no nucleus?

9 Metaphor from Albert Marshall.

10 Originally, aspirin was derived from the willow tree.

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