

GROWTH OF MULTIDISCIPLINARY SCIENCE IN THE PERIPHERY

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Abstract

This paper examines practice, growth and research associated with numerous experiential science, field studies and related place-based activities incorporated in a number Indigenous and rural communities in northern Canada. These approaches to science are presently being applied in the public school systems of the northern Canadian Territories (Yukon and Nunavut), and in numerous Cree and Dene Nation reserve schools in the northern Provinces of Alberta, Saskatchewan and Quebec. The research has followed students over a range of years following their engagement in these programs exploring their ongoing participation in the field of science and in community affairs.

The capacity for communities to direct and manage their own educational programs has been a central concern particularly in rural, remote and Indigenous communities. Characteristics of peripheral communities provide opportunities to initiate and manage various conditions of social change. This paper identifies those characteristics that favor educational approaches that require changes in how schools organize time, teaching staff, and curriculum offerings. These include experiential and place-based science approaches. These approaches have shown a greater engagement and improved outcomes of Indigenous and rural students.

Keywords: Multidisciplinary science, field studies, rural and indigenous communities, experiential education; place-based learning; student engagement; educational reform

Introduction

This paper examines practice, growth and research associated with numerous experiential science, field studies and related place-based activities incorporated in a number Indigenous and rural communities in northern Canada. These approaches to science are presently being applied in the public school systems of the northern Canadian Territories (Yukon and Nunavut), and in numerous Cree and Dene Nation reserve schools in the northern Provinces of Alberta, Saskatchewan and Quebec. Our research has followed students over a range of years following their engagement in these programs exploring their ongoing participation in the field of science and in community affairs.

Such initiatives were undertaken among these peripheral communities in response to concerns about student engagement, performance and ineffectual applications of conventional schooling. These conditions created an appetite for change. Significant variations to the ways in which time was used for instruction, the application of multidisciplinary approaches to many subjects and embracing instructional activities as social enterprises were the foundation principles of these initiatives. Within this broader context we have conducted research on the practice, growth and outcomes of multidisciplinary science programs.

The Settings

We build upon Reeler's (2007) use of the terms 'core' and 'periphery' to distinguish between the urban and rural areas in which differ in their concentrations of economic and

political power. “The conventional division in the world today between urban/core policy-makers (and their theorizing) and local practitioners is deeply dysfunctional, leaving the former ungrounded and the latter unthinking” (p. 3). The relationship between the *Core* and the *Periphery* is increasingly being shaped by a trend of developing Projects, and paying people as service providers to achieve centrally determined outcomes. The core most often sees Project interventions themselves as the change stimulus and processes. Existing Indigenous social change processes, usually invisible to conventional analysis, is seldom acknowledged and is effectively reduced to irrelevancy – except where resultant active or passive resistance to change cannot be ignored.

Urban cores tend to concentrate economic, political and capital infrastructure. Educational institutions in core areas tend to be large complex organizations and structures. Schools are often governed by an institutional inertia that makes operative change difficult requiring sustained energy and focus (Fine & Somerville, 1998). These educational systems, often secondary schools, are typically organized about specific subjects where teachers may teach a single subject within repeated blocks of time. Teachers are typically older and have extensive experience in teaching a narrow range of subjects using traditional didactic instructional practices. The timetabling tends to be inflexible and students are thrown together in different groups each timetable rotation. A teacher may encounter more than 100 students each day and after the semester may not see the cohort of students again throughout their secondary school career.

Rural and Indigenous communities function so that change is initiated at the community level (Barnhardt, 1999; Emekauwa, 2004). Typically, people living in rural and Indigenous communities have an ideology of environmental, community and economic interests setting them apart as a culture distinct from core populations (Gladden, 2001). Such communities have some unique opportunities to develop and implement educational approaches leading to an early engagement in multidisciplinary approaches to science (O’Connor, 2010). In this paper, we examine three different social change processes as defined by Reeler (2007), to explore dynamics related to changes in educational institutions in the periphery.

We use *Indigenous* to refer to the conditions, rights, and way of life of many groups, cultures, communities and peoples who have a historical continuity or association with a given region or parts of a region before its subsequent colonization or the formation of a Nation-State. We do not wish to insinuate by the use of a single reference that Indigenous people can be classified by one term that excludes each group’s specific and particular identity. We have learnt that not only are there definite relations and nuances within Indigenous Nations but they are explicitly specific within each community and reserve. The historical specificity and variability of culture and its synchronous interaction with many other diverse environmental and social structures create specific identities amongst groups that are not to be trivialized by a single term.

With the increase in land claim agreements, renegotiation of treaty rights and local control of resource development, the quest for self-governance by Indigenous people and rural communities is a motivating factor for improving education. This direct control and involvement leads to issues of preservation and sustainable development of their resources. There is a great need to reconnect schools with their communities, so as to provide opportunities for students to contribute to their community and also benefit from the opportunities before them.

Dynamics of change processes institutions

The undeniable interest attributed to Sir Ken Robinson’s call for *Changing Education Paradigms* in his Royal Society for the Arts presentation (Robinson, 2012) represents a growing unrest in public support for current educational processes. He argues that the

industrial model that many educational institutions pattern themselves upon is both crippling and nonresponsive. Robinson's presentation identifies how contemporary approaches to many subjects are ill suited to the needs of our creative and innovative world today. Calls for educational change are supported by a wide variety of historical and social analysis (Dewey, 1916; Foucault, 2002; Freire, 1970; Giroux, 1997; Kincheloe, 2005), but these calls often do not address the "how" such change could take place. This paper identifies such change processes as they may apply to communities at the periphery. Institutions, even those in the periphery, possess an inertia that compels organizational patterns that follow long standing practice that often resists alternative paradigms.

Emergent change is change originating with lived experiences

Emergent change describes the day-to-day unfolding of life, adaptive and uneven processes of unconscious and conscious learning from experience and the change that results from that. This applies to individuals, families, communities, organizations and societies adjusting to shifting realities, of trying to improve and enhance what they know and do, of building on what is there, step-by-step, uncertainly, but still learning and adapting, however well or badly. (Reeler, 2007, p. 10).

Cartesian modernists have the tendency to generalize, and through this process it prevents the development of a certain understanding of the uniqueness of the human experience (van Manen, 1990). With the promotion of "ultimate truths" and the need to own those truths in a capitalist-like banking of knowledge, there is little validity put on ones' lived experience. This goes against the principles of experiential science education, in that learning takes place through direct experience, by action and reflection. The learner assesses the experience, assigning their own meaning and understandings as they relate to learned scientific principles, goals, aims, ambitions and expectations. From this processing of the experience come the insights, the discoveries and the understandings that are generally referred to as experiential learning (Dewey, 1938). As this processing takes place, the pieces fall into place, and the experience takes on added meaning in relation to other experiences and previous knowledge. All this is then conceptualized, synthesized and integrated into the individual's schema of cognitive constructs which he/she imposes on the world, and through which he/she views, perceives, categorizes, evaluates and seeks additional experiences (Wright, 1970). "Lived experience has a methodical feature relating the particular to the universal, part to the whole, episode to totality" (van Manen, 1990, p. 36). A powerful description of experiences' relational aspects comes from Dilthey (1985): "lived experiences are related to each other like motifs in the andante of a symphony" (p. 227).

Varela (1999) provides a progressive description of the relation of experience in conscious thought. He claims that experiential structures are relational to conceptual understanding and rational thought. "The point is not that experience strictly determines conceptual structures and modes of thought: it is rather, that experience both makes possible and constrains conceptual understanding across a multitude of cognitive domains" (p. 16). This speaks to the learner as being privy to various forms of knowledge, and also exposed to various types of learning styles; the power of difference.

Transformative change is change through response to problems

At some stage in the development of all social beings it is typical for crisis or stuckness to develop. This may be the product of a natural process of inner development, for example the crisis of the adolescent when that complex interplay of hormones and awakening to the hard realities of growing up breaks out into all manner of physical, emotional and behavioural pimples. Another example is of a pioneering organization growing beyond the limits of its informal structuring and relationship's. (Reeler, 2007, p. 12)

Varela's (1999) enactivist ontology states that our identities are not pre-formed, and we often learn best when we empty ourselves of all that has been learned, towards what he calls the "virtual self" or "selfless self". "Knowledge appears more and more as being built from small domains composed of microworlds and microidentities" (p. 18). The key times to learn are in those "moments of breakdown" (Varela, 1999), or what Aoki (2005) would refer to as "moments of tension", when we are no longer experts of those microworlds and we become beginners who search for ways to understand what is foreign (through deliberation and analysis) so that we may feel comfortable and at ease with the task at hand. This speaks to experiential and place-based science programming strategic inclusion of adversity and resilience into curricular delivery and content.

It is a radical notion for many educators to envision that wisdom can be gained through a variety of traditions. The applications of enactivism as pedagogy have tremendous implications for experiential science educators, as they provide a rationale for providing diverse experiences and environments in the process of learning. This goes beyond the general tenets of experiential education that: promotes context therefore engagement; addresses diverse learning styles; and, encourages the integration of subjects. It provides a progressive rationale that we hope will provide other educators with a better understanding of the benefits of experiential science methods.

To advocate to students the need to empty ourselves of our pre-learned "baggage" and become beginners, open and eager to experience the "new", is a concept that has powerful possibilities for learning. It begins the journey to selflessness, in which we can begin to understand the creation of a self that is socially constructed (and can be reconstructed) in different environments and through various experiences. This is congruent with Vygotsky's (1997) concept of the zone of proximal development (ZPD), in which the social context shapes the range of learning that takes place. We propose Varela's (1999) search (based on Taoism, Confucianism and Buddhism epistemologies) for the selfless self and ultimately a virtuous self, is one that many experiential and place-based science educators should put into praxis, as it has positive implications for character building, critical personal reflection and a promotion of a socially just community.

Projectable change – Working with a Plan

Human beings can identify and solve problems and imagine different possibilities, think themselves and their present stories into preferred futures, being able to project possible visions or outcomes and formulate conscious plans to bring about change towards these. (Reeler, 2007, p. 14)

Numerous plans have been developed by small communities to address educational needs of their youth. These differ from the "planned project approach" developed by the core areas to "solve" the problems of periphery schools. Small communities are able to plan adaptable approaches that encompass community contexts, resources, and skills. Such community plans are characterized by their flexibility and responsiveness to changing community conditions.

Change in educational systems – periphery problems and opportunities

These are not the problems of someone else. They are our problems. We need to find solutions, not have ones passed down to us. We can learn from others, but our own experiences are paramount. Don't tell us what to do, give us ideas, access to resources and discussion, then let us work it out. (Kleinfeld, McDiarmid & Hagstrom, 1985, p. 89).

The peripheral community, by their very nature, have attributes favoring a range of social change processes that differ from those found in the "core". An analysis of rural Alaska High Schools identifies these as "rural advantages" that are often ascribed as similar to the benefits associated to private schools (Kleinfeld, McDiarmid & Hagstrom, 1985).

Children can grow up at home with their families

In small high schools, children receive a great deal of individual help and attention from teachers who know them well.

In a small high school, children are participants, not spectators.

Small rural high schools offer students increased access to special educational opportunities, such as the chance to travel and lots of time on the computer.

With the schools nearby, parents can exert considerable control over their children's education.

Local high schools enable communities to teach local cultural traditions, languages, and subsistence skills.

Local high schools provide such important community facilities and services as gymnasiums and workshops, spectator sports, newspapers, and community education programs.

A parallel and more in-depth study in rural Yukon Schools added to this list of opportunities for change found in rural communities (Sharp, 1985).

The small size of peripheral communities means that most people know each other, they are part of the same community and they are aware of their issues and have understandings how they may be addressed.

Smaller communities possess greater institutional adaptability and flexibility. Schools in these communities are more responsive to community concerns and disposed to providing programming designed to engage students and respond to community concerns. Community resource people are known to schools and to teachers.

Teachers are often required to teach a variety of courses across many grades. They are required to approach a variety of subjects with an integrated perspective because of their diverse teaching load.

Community issues and problems are more accessible to school as study topics.

Many smaller communities are starting places for young teachers, as young teachers their educational training has often included more contemporary understanding about diverse instructional practices that engage students, understanding of neurological processes, and the value and involvement in instructional communities.

The absence of institutional resources encourages communities to develop their own resources from locally accessible materials.

Limited course offerings encourage students to explore topics they might otherwise overlook.

As educational practitioners, we acknowledge the complexities associated with the process of change and therefore confirm the need to be cognizant to the dynamics of change, to be thoughtful, diligent and regulate practice accordingly. This is not a simple practice, one that challenges science educators to think critically regarding social conditions which begins by addressing emergent, transformative and projectable forms of change. Given the need for a more responsive educational approach, and based on opportunities associated with rural and Indigenous educational environments, we will provide a number of alternative educational approaches below that were developed in recognition of the various conditions of social change.

We begin with a focus on the development of educational approaches that involve integration of curriculum across disciplines, addressing local situations as a means of providing relevance to school studies and using collaborative approaches to schooling. Experiential and place-based approaches have been a logical extension of the rural educational setting. Experiential and place-based initiatives have become a major factor in education, as many Indigenous and rural northern Canadian communities move toward greater autonomy and self-determination: to encourage students to be aware of, and feel responsible for the lands their ancestors have occupied; and, to better prepare and encourage the students for employment opportunities that exist within rural territories and beyond. Initiating experiential and place-

based approaches require changes in the ways in which schools organize their time and instructional processes. These approaches require flexibility in scheduling integrating and combining courses, and changing relationships between student and teacher.

Experiential and placed-based science initiatives have been created to address the lack of success and disengagement amongst Indigenous and rural students in formal schooling. Such initiatives take many form and themes. Within the sciences, a holistic form of science education has evolved. A form that values the importance of ‘place’ and the role of cultural knowledge within the disciplines of what some would consider “formal science” and also more cultural interpretations such a traditional ecological knowledge. The balance of this paper examines a number of approaches in which peripheral communities have used multidisciplinary approaches to science and restructured school experiences to build on the strengths of such communities.

Research Methodologies

Our action research studies—utilizing anecdotal evidence, semi-structured interviews of a sub-set of students, teachers and administrators, and end-of-semester focus groups and anonymous surveys and questionnaires has revealed several key factors related to the concept of place and its relationship with social change processes that contributed to the positive outcomes of these multidisciplinary approaches to science education.

The surveys of the students who took part in the experiential and place-based science programs between five and nineteen years ago (2008-1994) explored many aspects of their life following secondary school (grade 12). Information was collected across this time span through email responses, phone or in-person interviews and focus groups. The analysis of this program is still ongoing.

Data was analyzed using methods of constant comparison to identify emergent patterns and themes (Erickson, 1986; Lincoln & Guba, 1985; Patton, 2002) within and across sites.

Periphery schools – examples of change

There have been a number of programs and approaches developed in peripheral communities that have built on the various aforementioned conditions of social change. Four of these approaches are described below.

Experiential Science Programs: One response to these conditions have been the development of multidisciplinary science programs in which a single teacher teaches a cohort of students across three or more fields of traditional science core courses for a semester. In these programs, the courses are built around experiential models of learning, attention is given to community topics, time allocation is flexible to meet study demands and the cohort of students work in collaborative problem solving contexts. Some of these programs have been functioning for more than twenty years and our research has followed cohorts of these students since they were involved (O’Connor & Sharp, 2013).

Our research shows overwhelming success across a number of dimensions. A significant proportion of these students remain engaged in sciences in subsequent undergraduate and graduate studies. More than 80% complete university, compared to less than 50% from the larger rural student population. Many of the field studies associated with the studies undertaken by the cohorts of experiential science programs have assisted communities understand and address local problems.

Rural Experiential Models (REM): Another response has been the development of alternative ways of offering courses in weeklong blocks of time. This approach was more readily accommodated within rural high schools. The course offerings were designed around surveys designed to gain the interests of students. The science-based weeklong courses focused on experiential elements and field activities. The REM courses were typically built

around experiential models of learning, focused on community topics and the cohort of students work in collaborative problem solving contexts. Some REM programs have been functioning for more than twenty years.

Research following REM programs has shown high levels of student engagement and ongoing teacher involvement (Kleinfeld, McDiarmid & Hagstrom, 1985; Sharp, 1985, 2007). They have involved a wide range of community support and community members volunteering in a range of REM activities. The REM approach can be part of smaller schools because of both scale and the teachers' knowledge of the students.

First Nations Land-based and cultural programs: A third approach has been undertaken by a number of Indigenous communities involving groups of students in land based activities based on a blend of cultural traditions and contemporary science. These activities honor Indigenous traditional knowledge and provide a medium that integrates science with Indigenous knowledge. These types of programs have been embraced by many Indigenous communities where the activities are credited and linked with other fields of study. In order to credit such activities, curriculum outcomes were identified along with ongoing assessment strategies. These were designed to bridge many areas of traditional knowledge and ways of understanding with contemporary sciences (O'Connor, 2009; Sharp, 2005).

Place-based activities addressing community concerns: The fourth approach we describe is a more general method of embedding multidisciplinary science initiatives within school programming. Place-based education seeks to help communities through employing students and school staff in solving community problems. Place-based education differs from conventional text and classroom-based education in that it understands students' local community as one of the primary resources for learning. Thus, place-based education promotes learning that is rooted in what is local—the unique history, environment, culture, economy, literature, and art of a particular place (Kawagley & Barnhardt, 1999). Addressing a variety of community problems brings into play many different aspects of science, engineering and mathematics. The “problems” call for solutions requiring multidisciplinary approaches. When students deal with “real” issues and work with community members to find solutions they become engaged. The engagement spills into many fields of science.

Examples of such place-based activities include working to reintroduce salmon populations, addressing problems of highway litter and solid waste, monitoring water quality in community water courses, recording forest structure and growth rate. Most of these activities take place over a period of years. Students build on the work of their older peers and may follow a project over a period of years, growing with knowledge and skills related to the “problem”.

Through a recursive process of data analysis, specific themes emerged in our research that was deemed crucial to experiential initiatives. We explored those themes through the participants' voices. They were: the importance of *Partnerships* within the community; the application of alternative forms of *Evaluation*; the use of *Field Studies* to deliver curriculum and engage students; an incorporation of *Indigenous Culture and Knowledge* in many aspects of the educational context; and the issues of *Sustainability* that include alternative structures and scheduling of the experiential and place-based science programs (O'Connor, 2010).

Lessons Learned

This paper supports the call by many authors who cite the importance of educators modeling constructivist approaches to science education that engage students in interdisciplinary exploration, collaborative activity and field-based opportunities for experiential learning, reflection and self-examination (Cajete, 1999; Carlson, 1999; Dewey, 1938; McGinnis & Roberts-Harris, 2009; O'Connor, 2009; Rogers, 1969; Sharp, 2007; Tyler, 1949). Using an experiential model that supports reflective inquiry, students learn to appreciate the myriad of ways that science curriculum and pedagogy can be linked to real life

experiences. Students make discoveries and experiment with knowledge first hand instead of exclusively hearing or reading about the experiences of others, often who are considered to be real “scientists”. Students also reflect on their experiences and share them with other active participants in such environments as weekly sharing circles and also, in the less formal settings of school cohorts. Through this process they develop and share new skills, new attitudes and new theories or ways of thinking about science. Students then use this cognition to make informed decisions about scientific endeavors in and outside of the classroom, with the security that they are supported in partnerships.

This experiential science model helps create an educational climate where students can develop into engaged, critical and empowered learners of a diverse and complex globalized society (Bayne, 2009). Pedagogical decisions are based on the teachers’ insights into consciousness construction in the experience of themselves and their students, the interaction of the collective and the personal, diversity, social and educational theory, and instructional strategies. Such informed teaching creates unprecedented levels of awareness and higher forms of cognitive activity in the field of science.

Through the use of extended science field studies that promote experiential and place-based learning, and critical investigations supported by school-community partnerships, students become intimate with the dimensions of their science-based schooling and in society in general, that has been often missing in regular school programs. The teachers of these science programs are now engaged in an educational praxis that raises the conceptual and ethical value of the science education profession and better reflects the present climate of our society today.

Experiential and place-based science educators face the challenge of incorporating some or all of the principles aforementioned while avoiding simple “lip service” through the act of tokenism. Experiential science initiatives, such as a community presence in the school or the incorporation of student journals and self-assessment alone may not lead to improved discourse and less hierarchy. Many students, who have been habituated to their role as passive recipients of knowledge (Freire, 1970; Kincheloe, 2005) may find difficulty and provide resistance with this alternative methodology. This is why we think we need to reconsider the teacher’s role as dictatorial and consider them as facilitators, as it is crucial that they guide transactional relationships between teacher-student and student-teacher. It is the responsibility of teachers to engage in meaningful, experiential and critical praxis of science with students, while avoiding an authoritarian paternalism (Breunig, 2005).

Many experienced educators who have attempted, or are providing, experiential and place-based science praxis speak of its challenges (O’Connor, 2009; Raffan, 1993). Issues of institutional adversity, academic science mistrust, parental resistance, extra time constraints with respect to student-centered learning and activity preparation, funding, legal implications of field activities, and a lack of teacher training in post-secondary institutions are all valid. With that acknowledgement, the majority of our studies’ participants speak to the benefits outweighing the negative, as the application of an experiential and place-based science praxis is crucial toward a vision of a more effective pedagogy towards the preparation of the learner within a socially just world. The advantages from the student, teacher, school and community’s perspective is unlimited, as long as those theoretical and practical components are enacted in a mutual praxis.

It begins with the new generation of teachers, as a better collaboration between theorists and teachers is needed to reinforce the congruence of theory and practice in post-secondary science teacher education programs (Raffan, 1995). Imparting theoretical knowledge is no longer sufficient, yet promoting an isolated experience that lacks intention, purpose and meaningful reflection is also inadequate. Literature on place-based and experiential science education has predominantly grounded itself in “soft skill” environmental or outdoor educational practices. Its location in the school’s curriculum is often limited to its

own specific subject matter (i.e. as Physical Education and Mathematics are found in a school's curriculum). More research is needed in the practical applications of this type of programming, which actually drives the overall operation and philosophy of the school in order to study the application of these methodologies in diverse school environments that incorporate varying learners, cultures and communities.

New science pedagogy is needed that incorporates the best of the fields (experiential/place-based science pedagogy) that is rich in both theory and practice. One that provides substance to the fields' application towards a purposeful science classroom and that incorporates critical learners actively in the development of a science learners identity that will sustain them in good standing in a socially just world. We call for science pedagogy of generative praxis that teaches "in ways that will help each learner walk home experiencing their world differently because of what they learned in school that day" (Jardine, 2005, p. 4). A pedagogy that invests each student with a sense that they can be agents of change on the basis of how and what they learn.

The capacity for communities to direct and manage their own educational has been a central concern particularly in rural, remote and Indigenous communities. Characteristics of peripheral communities provide opportunities to initiate and manage such change. These characteristics favor educational approaches that require changes in how schools organize time, teaching staff, and curriculum offerings. These include experiential and place-based science approaches. These approaches have shown a greater engagement and improved outcomes of Indigenous and rural students. In summary, these programs are practical applications of experiential education and multidisciplinary science as praxis.

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