Contextualized Science Outreach Programs: A Case for Indigenizing Science Education Curriculum in Aboriginal Schools

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The objective of the study was to identify educational needs and strategies required for effective outreach program development and implementation in Aboriginal communities. How science is perceived by Aboriginal communities, similarities and differences between Aboriginal worldviews and Western Science, and culturally inclusive teaching provided the context for the research. Through a sociocultural lens, a mixed-methods case study design was employed in an Aboriginal school in Eastern Ontario. Data included survey responses, observations, curriculum materials, interviews, and reflections. The findings show the following should be included in science outreach: culturally relevant hands-on/ experiential learning activities, so as to honour traditional Aboriginal perspectives and knowledge; programs reflecting more learner control and choice to promote student agency, whereby students see themselves doing science and becoming potential scientists; and activities that highlight cognitive and cultural conflict (e.g., excessive writing) and enhance frustration (e.g., reliance on numeracy) should be re-assessed to acknowledge the difference between Aboriginal student's cultural identity and the culture of school science.

INTRODUCTION

SCIENCE OUTREACH PROGRAMS AND SCIENCE EDUCATION

Outreach programs such as science camps and clubs provide valuable experiences that ignite interest and demonstrate how technology and science connect to everyday life and careers, and allow students to expand their skills (Rahm, Martel-Reny, & Moore, 2005; Thomasian, 2011). Not only is it important for students to participate in activities outside the classroom, governments and educators need to address how to make classroom learning in science more engaging, specially through professional development opportunities that assist teachers in developing confidence and becoming comfortable with the subject, and subsequently engaging their students through classroom activities (DeCoito, 2014; Franz-Odendaal, Blotnicky, & French, 2014). The research being reported directly addresses the aforementioned goals of science education and teacher professional development in classrooms through a study of an outreach program, Science Outreach Program (SOP). SOP is a leading science outreach charity dedicated to sparking children's interest and love of science, technology and the environment through hands-on inquiry. Hands-on inquiry is advocated for by among others DeBoer (1991), and, Minner, Levy and Century (2010). Following, SOP's mission is to ignite scientific wonder in children through investigative half-day workshops, guided by the knowledge of scientists.

Given this mandate, SOP has the potential to effectively promote contextualized science education in Aboriginal contexts, as has been promoted by National organizations for science and science education, such as the Natural Sciences and Engineering Research Council of Canada (2010) and the National Science Foundation (2008). These organizations have been advocating outreach and encouraging the involvement of scientists and engineers as provided by outreach programs such as SOP, in K-12 classrooms to support teachers and engender scientific literacy for students. Arguably, outreach programs have the potential to provide valuable experiences that ignite interest and demonstrate how math, technology, and science connect to everyday life and careers, and allow students and teachers to expand their skills through inquiry processes.

Additionally, according to the First Nation, Métis and Inuit Education Policy Framework, there is an established need to implement strategies to enhance Aboriginal students' participation in the sciences, because of the trend of low participation rates in postsecondary education and a significant under representation of Aboriginal peoples in science and technology occupations (Ontario Ministry of Education, 2007). Research suggests that there is need for strategies to motivate Aboriginal students and increase their participation in the sciences and in science occupations (Jaipal, Engemann, & Montour, 2009). The research and discussion about Aboriginal students and science learning is a national phenomenon that is relatively new and still undergoing change (Allen & Crawley, 1998; Baker, 1996; Cajete, 1999; Ganambarr, 1982; Harris, 1978). The reported trends are prevalent because secondary schools do not adequately prepare Aboriginal students in general for the reality of the workforce or advanced studies (Battiste, Bell, & Findlay, 2002; McCue, 2006; Orr, Roberts, & Ross, 2008; Taylor & Steinhauer, 2008). Notably, a concerted effort to prepare Aboriginal youth will ensure that they do not lack essential numeracy and literacy skills required for the workforce (Alford & James, 2007; Finnie & Meng, 2006), and that they are not discouraged from taking rigorous coursework in middle and high school that will prepare them for success in postsecondary endeavours (Faircloth & Tippeconnic, 2010). One potentially very effective avenue for addressing the needs of Aboriginal learners in science and numeracy is through outreach programs in science classrooms, especially through the inquiry process. This will be in keeping with the Policy Framework.

The stipulations of the Policy Framework, such as teacher professional development, inquiry and hands-on learning, science for relevance, effective learning strategies, and so on, parallel the goals of SOP, which include presenting science and technology concepts using a hands-on/inquiry approach to enhance students' attitudes toward science and to foster an appreciation and awareness of science and technology amongst *all* children, regardless of gender and ability. SOP's vision includes inspiring elementary students and teachers to enjoy science and technology through fun and exciting activities. Specifically, SOP seeks to "inspire greater understanding and interest in all young minds" and to "expose students to the excitement and enjoyment of scientific discovery" (Science Outreach Program, 2010). Ultimately, SOP's workshop leaders hope that by doing this they will encourage students to pursue science in high school, and ultimately choose to remain engaged in scientific and technological fields.

TEACHING INQUIRY IN ONTARIO ELEMENTARY SCHOOLS

Inquiry learning often involves classroom activities where students interact with materials and other students as they investigate the world around them. Inquiry-based science education has been characterized in a variety of ways over the years. Some have emphasized the active nature of student involvement (i.e., "hands-on" learning activities) while others have focused on the development of an understanding of inquiry processes such as the steps of a scientific method and the process skills required to perform scientific investigations (DeBoer, 1991). This mode of learning has been strongly advocated for all students, irrespective of culture, gender, and class. A focus on scientific inquiry places new intellectual and practical demands on science teachers and students alike. For example, teachers are charged with the responsibility of providing as many hands-on activities as possible in Ontario's grades 1 to 8 Science and Technology curriculum, as inquiry and design skills are emphasized in order to allow students to discover and learn fundamental concepts through investigation, exploration, observation, and experimentation (Ontario Ministry of Education, 2007). While curricular explanations and learning expectations are a good place to start, teachers must learn new teaching perspectives, and plan lessons that build on students' understandings of scientific phenomena and the nature of scientific inquiry (Davis, Petish, & Smithey, 2006). Furthermore, if teachers are to facilitate learning in ways consistent with scientific inquiry, they must know the processes of science and be proficient in the practices of science; an assumption challenged by research showing that many do not have adequate insight into how scientific knowledge is developed (Bencze, Bowen, & Alsop, 2006). The reality in schools is that elementary teachers lack a practical pedagogical framework to inform their inquiry-based instructional plans (Bell, Smetana, & Binns, 2005). Moreover, elementary teachers do not possess science content knowledge and struggle to see the conceptual links between the various domains of knowledge (Lederman & Lederman, 2013).

According to Hogue (2012), much of Western science is curriculum-driven and textbook taught; a way of teaching and learning that is different from Aboriginal ways of coming to know. Hogue maintains that "experientially-based learning situations provide applicability, which in turn provides relevancy for Aboriginal learning and is critical to bridging theory and practice" (p.99). Furthermore, Barell (2003) has stated, "We need inquisitive people to grow into this new millennium" (p. 18) and claims "wonder, inquiry, skepticism, and doubt [are] the pillars of our civilization, the promise of our future on the planet" (p. 22). This instructional model requires the teacher to let go of some of the leadership in the classroom, while still being accountable to learning goals set by the province (Stacey, 2009).

RESEARCH QUESTIONS

The current paper is part of a larger study which reported on the potential of a science outreach program to address educational needs of Aboriginal communities, and possibly increase interest and participation rates in school science, and ultimately, science careers. This paper reports on the following research questions: How is the outreach program meeting the gaps/barriers in Aboriginal communities in Ontario?

How might the outreach program meet the gaps/barriers in the future?

THEORETICAL FRAMEWORK

The research was informed by the sociocultural learning theory in the context of a post-colonial framework. Post-colonial framework is the discourse that deconstructs and resists schools' attempts to impose grand narratives on educational practices; the narratives that predominated education in the colonial empire during British colonial rule and that are perpetuated in various forms today. The discourse also finds respectable approaches by which to bring together different ways of knowing, for instance Aboriginal epistemologies and Western epistemologies (Dei, 1999; Hogue, 2012; Munroe, Borden, Murray Orr, Toney & Meader, 2013). One way to resist colonial tenets is to adopt learning theories that are cognizant of sociocultural contexts. A fitting theory for this purpose is the sociocultural learning theory which begins from the premise that science is a socio-cultural system: "As a socio-cultural system, science is an integrated whole intimately interrelated with human activities and a process that can be presented from the non-Western high contextual/cultural perspectives in valid and internally consistent ways" (Cajete, 1999, p. 154). The underlying assumptions for this theory is that learning occurs in social and cultural environments whereby those who already know the content of what is to be learned (experts), induct those who are new to the domain of knowledge (novices). The induction or helping another to learn, involves cultural tools as the spoken language and its associated symbols of representation. For example, a girl or boy (novice) who needs to learn how to recognize the stars is taught how to do so by an older woman or man, not necessarily an expert astronomer, but one who knows how to recognize heavenly bodies by tying the knowledge of the stars to cultural knowledge in everyday life. In this case the expert astronomer helps the novice guided by the features of how people learn as espoused by Bransford, Brown, Cocking, Donovan, and Pellegrino (2000). That is, by prompting the learner to notice where there is knowledge and/or skills gaps and guiding the learner up through the various notches of understanding, employing elements such as scaffolding, attending to Vygotsky's (1986) zone of proximal development , and using metacognition strategies to master the art of star recognition. Rogoff (1998) noted all these elements in operation in sociocultural learning contexts.

Similarly, Chinn (2007) maintains that learning "cannot be dissociated from interpersonal interactions located in cultural frameworks … [and that] values, emotions, experiences, and cultural contexts are integrally related to learning" (p. 1250). Furthermore, sociocutural learning theory seeks to address human learning at the individual and collaborative levels, by investigating and integrating learning concepts, empirical and theoretical concepts from many disciplines such as anthropology, sociolinguistics, sociology, history, and psychology (Rogoff, 1998). Additionally, sociocultural learning theory helps educators think about human learning in cultural contexts and is applicable to the study being reported on a science outreach program in an Aboriginal context. As already stated, this perspective to learning "emphasizes characteristics of social participation, relationships (such as that between novice and expert, newcomer and old timer), the setting of activity, and historical change" (Packer & Goicoechea 2000, p. 227).

The relevance of the sociocultural learning theory for researching Aboriginal contexts is undeniable. For instance, Aboriginal students in science classes are likely to possess a traditional knowledge system that is different from the conventional science typically taught in schools. In this respect, Munroe et al. (2013) and others (Aikenhead & Michell, 2011; Alcoze, 1992; Allen & Crawley, 1998; Fleer, 1999; Gitari, 2006; Hodson, 1993; Kawagley, 1995; Martin, 2012) advocate for teaching numeracy and literacy in context so as to incorporate an Indigenous worldview which is holistic and interconnected. Furthermore teaching these disciplines out of context goes against developing critical thinking and problem solving skills. This implies that culturally-specific pedagogies need to be adopted in classrooms to support Aboriginal students in their learning. Pedagogically, moving from one cultural setting to another (e.g., from home to school, or from a peer group to a science classroom) is conceived as cultural border crossing (Aikenhead, 1996). For this reason, school science requires most students and their teachers to cross boundaries (border crossings) between the cultural context of their home, family, and community (i.e., traditional knowledge, language, beliefs, values, and ways of knowing) and the context of Western science. The exclusion of diverse epistemologies, the subject of Martin's (2012) article summarizing Mi'kmaw Elders Albert and Murdena Marshall's '*two-eyed seeing*', is particularly relevant in the context of failed border crossings among Aboriginal students in the sciences. Two-eyed seeing is a guiding principle and a way of respectfully joining Western science and Indigenous knowledge, in which diverse worldviews are made to coexist equally. Referencing Iaccarino's (2003) work, Martin (2012) describes Western science as "positivist science" or "positivism" – that is, it purports that there is a single truth that can be revealed by scientific procedures; however, many important scientific discoveries have been made outside of this rigid framework. Furthermore, science as a discipline was re-appropriated and made largely inaccessible except to the privileged, thereby separating many scientific truths from their original (often Indigenous) sources (Alcoze, 1992; Gitari, 2003). Two-eyed seeing is a way to continually evaluate and eliminate biases toward one perspective over others by acknowledging varying epistemologies, since no one perspective is complete. It also allows for a fluidity that is truer to our changing physical and social environments.

RESEARCH METHODS AND PARTICIPANTS IN THE STUDY

A post-colonial theoretical framework was preferred for conducting this study as it sensitized the researchers to the dynamics of an Aboriginal sociocultural context when addressing the goals of the study and also the need for the two-eyed seeing pedagogical framework. The researchers/authors are of non-Aboriginal backgrounds. We are both of ethnic minority background and we both work and live in the province where the study was conducted, in Ontario, Canada. Our desire to learn about education in Aboriginal contexts stems from our interest in the broad field of access and equity in science education and ongoing experience educating Aboriginal Canadians in higher education. Because we are not of Aboriginal origin, we are sharply aware of the fact that in conducting research in a context different from one's own, we were obliged to enter the field as cultural foreigners seeking to learn the views of the residents/participants. In the qualitative research paradigm, the views of the participants are referred to as *emic* and those of the researcher, as *etic* (Creswell, 2007) because it is recognized that the views will be different. For that reason, we needed to adopt Aikenhead's (2006) notion of *cultural anthropologist* for science educators, for the entire research exercise. Aikenhead uses the term cultural anthropologist to help science teachers envision science as another culture, as different from the majority of students' ways of understanding and interpreting the world. We found the notion helpful because it is described in relation to science education. Being a cultural anthropologist means that one approaches the foreign culture focused on the desire-to-learn, suspending judgement that is based on prior knowledge about the foreign culture, in our case, education in Aboriginal contexts, and adopting the attitude of a learner (Spindler, 1963).

We contend that an approach which warranted a case study, with researcher(s) in the field, effectively addressed the research questions and provided deliverables and further insight into areas that require additional investigation. Hence, a mixed-methods case study (Creswell, 2007; Mills, Durepos, & Wiebe, 2010; Tashakkori & Teddlie, 2003), was utilized for the study, which was conducted over twelve months (June 2012 –June 2013), to help meet the overall aim for the project and answer specific research questions.

Skénnen Elementary School (pseudonym) is located in eastern Ontario and was built 37 years ago on a site that was initially the home of one-room schoolhouses, some of the first Aboriginal day schools on Native territories. The school's character education curriculum is focused on the story of the Peacemaker (Barnes, 1984). The Peacemaker story is illustrated in a wall mural upon entering the school, to symbolically depict the ethos of the entire school, conceptualized as character education. In all, the Peacemaker story and associated symbols represent the educational philosophy of learning at Skénnen School. The student population is approximately 300, whereby 93% of the student population are residents of the territory and are of Mohawk descent, while the remaining 7% includes stepchildren and/or child/children of a partner. The teaching population is composed of 21 federal staff, 3 Band staff, and 11 education assistants. All teachers are members of the Ontario College of Teachers, and federal staff is considered federal employees, while Band staff is hired by the Band directly. Ninety percent of the teacher population is of Mohawk heritage, while 10% belong to other heritage groups. The principal, Sandy[4], of the school has occupied the administrative role for 8 years, and she is a member of the Band.

The participants included elementary students and science

4 This and all other participant names are pseudonyms.

educators at Skénnen School. Two grade 4/5 classes and one grade 5 class were involved in the study. Three science educators (two males and one female), 18 students (13 females and 5 males), and an administrator (female) consented to participate in the study. Two of the teachers (one female; one male) are Mohawk, and the other male is English Canadian. All students are of Mohawk heritage.

The three educators have had different experiences teaching science, as well as different educational backgrounds. Doug had completed his teacher education qualifications and taught at the primary/junior/intermediate levels for 11 years. During the study, he taught grades 4/5. Fiona had been teaching for 13 years at the primary/junior level and was teaching grades 4/5 during the study. Don had taught for 15 years and was qualified to teach native studies, with one year of additional science qualifications in environmental science, biology and physical geography. He had also taught with Corrections Canada and was teaching grade 5 during the study. Sandy is also a science educator.

Data collection occurred over a twelve-month period and consisted of ten visits (6 hours each) to Skénnen School to gain a better understanding of the science outreach program, and educational opportunities present in the school and school community. Each of the three classes participated in 2 different workshops (e.g., grade 4/5 - gears and pulleys, and rocks and minerals; grade 5 - the body, and chemical changes,) in November and December 2012. These workshops align with the expectations of the various strands in the Ontario Curriculum, Grade 1-8 Science and Technology, and provide hands-on activities to support learning of science concepts. The data collecting methods for this study consisted of non-participant observation, in-depth interviews (Rapley, 2007), surveys, and document analysis using Ninnes (2000) analytical frameworks. Data collection for the study was conducted during normal classroom instruction time and the primary sources of data for this study were i) teacher and student survey responses, ii) classroom observations of instructional episodes (4 observation visits), including SOP workshops, iii) curriculum materials that teachers created for students, iv) teacher, administrator, and student interviews (individual and focus group), and v) student reflections post-workshops. Teacher surveys explored teachers' views, interest, and knowledge in science; teaching strategies in science; and knowledge and understanding of Aboriginal perspectives. Student surveys explored students' attitude and interest in science; learning styles in science; and knowledge of cross-cultural perspectives in science. Individual teacher and student interviews were conducted once during the study by one of the researchers and were approximately 20 minutes in duration. The teacher interviews further explored survey items on i) philosophy of teaching and learning science; ii) goals for science teaching; iii) views on cross-cultural perspectives; and iv) factors influencing their teaching practice. The student interviews further explored i) students' responses to survey items related to attitude, interest, and views of science; ii) outreach programs and school trips related to science; and iii) cross cultural perspectives in science education. Teacher and student focus group interviews explored the participants' experiences with the SOP workshops that were conducted during the study. Workshop observations included episodes of student engagement, inquiry, problem solving and decision making, experiential and hands-on learning, storytelling, and the inclusion of cultural contributions. This paper reports on teacher and principal interviews, teacher surveys, and classroom observations.

Quantitative data were inputted into Microsoft Excel and analyzed using statistical analysis and descriptive statistics. Qualitative data from workshop observations and interviews were analyzed through an interpretational analysis framework (Stake, 2000) to establish the potential of outreach programs to foster attitudinal and behavioral changes in students and enhance students' 21st century skills and learning in science education, as well as support teachers' own efforts.

FINDINGS: TEACHING SCIENCE IN AN ABORIGINAL CONTEXT

Survey results indicate that the science educators at Skénnen School science background mirrors their confidence in teaching science, including teaching science from the perspective of Aboriginal values, beliefs, and knowledge. In order to attain their teaching goals, accommodate diverse learning styles, and address some of the challenges in teaching science (i.e., lack of resources, time, to name a few), the teachers employed 'multi-dimensional' teaching strategies and relied on *different modes* to promote and foster effective learning in science. The different modes of teaching strategies include a) inquiry and hands-on activities to engage and ignite student interest in science lessons, b) videos/movies for visual learners, and c) incorporating technology, including SMART Board lessons. Hands-on activities were encouraged as this approach is considered a preferred learning style in Aboriginal culture, according to the participants in the study and a number of researchers (for instance Aikenhead, 2006; Cajete, 1999; Hampton, 1995; Snivley & Corsiglia, 2001; Sutherland, 2002). This is consistent with Gardner's multiple intelligences theory that is advocated by Indigenous educators, such as Cajete (1999). Despite not having access to resources to support teaching from cultural perspectives, Fiona expressed the fact that hands-on learning and oral communication are key to addressing the cultural perspectives of Aboriginal learners. This observation, which was also reiterated by Sandy, will be further elaborated upon in the discussion section. Sandy summed up the importance of adopting teaching strategies that address kinesthetic learners, a predominant learning style for the majority of learners at Skénnen Schoo:

> Our children are absolutely fantastic kinesthetic learners … that is the mode that connects with them most through any subject area, so every opportunity that I can have to make sure that that's happening, I take it, be it science, be it the arts, be it whatever the subject is, it's that mode of learning. (*December 14, 2012; Quote #1*)

As evidenced in the findings, the teachers also incorporated science into other units (e.g., language), utilized storytelling, and chunked information into smaller groups –sometimes using field trips, or keeping chunks to introduction, main idea, follow-up format, and condensing topics into one or two weeks.

In addition to interviews, the teachers were asked to rate the following survey items in terms of impact on their teaching practice: *I involve and invite feedback from parents and the community to improve my teaching; Outreach programs/field trips have increased my confidence in teaching science and technology; I am supported in my effort to teach science from the perspective of First Nations, Metis, and Inuit culture and values;* and *I participate in professional development opportunities specific to learning about First Nations, Metis, and Inuit science perspectives.* It is evident from Figure 1 that outreach programs and field trips have greater impact on the teachers' teaching practice at Skénnen School, when compared to board mandated professional development (PD) initiatives, community support, and community feedback. When asked about factors or influences that have impacted their teaching practice, a variety of resources were cited by the teachers. According to Doug:

> We have different festivals during the year, three different festivals. We have speakers come in, Elders come in, and then we would, around that week, take trips on the territory here, which would involve local area and local people. That was pretty interesting to do. We went to the Science Centre … we took a field trip there when the human body was on display. We went earlier to the petroglyphs up in Peterborough. (*December 14, 2012; Quote #2*)

Figure 1 illustrates the results from the 4 survey items (from left to right):

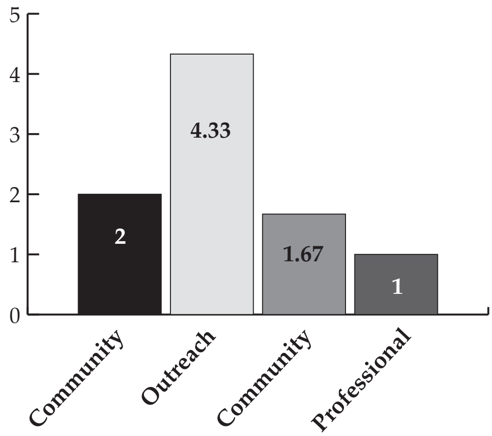

Figure 1. Impact of Community Influence, Outreach Programs, and PD on Teaching Practice

OUTREACH PROGRAMS: ADDRESSING GAPS IN TEACHING SCIENCE

Outreach programs have a significant impact on teachers' practices in the teaching and learning of science. According to Sandy, the outreach science workshops in this study are important for teachers, as well as their students:

> For teachers, I think that every time that they have a scientific workshop in their classroom, I think that they are learning. It gives them a sense of things and even if they have a take-away … they may not have the raft of resources that arrive with the workshop, of course, but they may take segments of the ideas to be able to make their science much more hands-on. The other thing is they

> get to see their students in a really hands-on learning situation and observe what the kids are doing, and I think that can really enhance their appreciation for students in their classroom and their varying learning strengths, particularly if a teacher tends to be much more lecture approach, and a child is not a strong auditory learner at all. However, students are completely engaged in the workshops…I think it functions on a number of levels to enhance the teacher's ability to teach, but also to help them observe their students' strengths. (*December 14, 2012; Quote #3*)

The outreach science workshops in this study pose a variety of advantages for the learning environment of students. First, they provide teachers with a focus (pre-workshop packages, post-workshop activities). Second, having a class participate in a workshop provides onsite PD for teachers as they learn pedagogical content knowledge and techniques for addressing different subjects that they could implement themselves at another time in their practice. Third, topics covered in the workshop provide a platform for teachers to extend into other topics, as illustrated in Fiona's response:

> Well, I like when the different science groups come to visit and they give either added information or added knowledge to the students and just an opportunity to use some of the materials that I might not have access to … it helps me to guide my teaching through the pre-teaching and learning, helps them get the most out of when we do have visitors here, so that they are knowledgeable and that they are not just starting at square one when we do have visitors in. So that they are able to participate and fully make the most out of the different workshops we have. (*November 29, 2012; Quote #4*)

Fourth, workshops provide resources for teachers that they may otherwise not have access to, have the time to incorporate into their lessons, nor know how to use them. Doug commented that the outreach workshops have positively affected his motivation and confidence the most in teaching science over the years:

> The workshops … the more aware I've become of the material I'm teaching. That helps me as a teacher, without having that background. Obviously when the scientists come in and they're participating with the kids and the sciences, I'm just reassuring what

> I already know and learning these things that I could help them, and new ideas so that I could teach my kids, as well. So it helps me, because sometimes when I take a look at what they're doing, and I try to think of some ideas of how I can extend that, and do it next year as well. (*December 14, 2012; Quote #5*)

Fifth, the chunk of time focused on a single topic helps students grasp materials. According to Don:

> … the shorter the chunking of it, the more time is spent on science and students lose interest. It would beneficial … like half a day. With the half-day science workshops, kids grasp more versus doing it in an hour or half an hour a day. (*November 15, 2012; Quote #6*)

ADDRESSING GAPS: 21ST CENTURY LEARNING, RELEVANCE, AND CULTURALLY INCLUSIVE PEDAGOGY

There are numerous areas that, according to the science educators, the science outreach program need to further develop in order to achieve target goals and address the needs of diverse learners. In addition to supporting teachers and demonstrating pedagogical strategies to enhance their classroom teaching, the science workshops have exposed teachers to technology that they can use in their classroom. For example, Don recollected his amazement during a workshop as he witnessed the presenter using a microscope that was hooked up to the SMART Board. The teachers suggested, however, that workshops could incorporate learning centres that provide further opportunities for students to work with technology, such as SMART Board and Promethean, which are readily available at Skénnen School. The fact that students like to multitask, there is room for workshop development around technology and digital resources, differentiating instruction, thus personalizing learning, that can potentially provide unique learning experiences for 21st century learners, as exemplified by one of the science educators:

> The kids like to multitask. So, for example, we could have a workshop leader in and they're demonstrating something and I have a Khan Academy video going on the SMART Board that's giving me another interpretation, and I have a group of kids looking something up on the Internet and … these things can all be happening, so that the content, the workshop content, and the hands-on tools that the

> person brings along with them, can become a station in a whole learning experience, so that the learner is self-selecting all over the place and the instruction is differentiated. …presenters will have to change their approach … they will, because they come in as the "all knowing," they're the outsider; they're the scientist, that's a tremendous value, but that's a value that I think is "running its gamut". So that has to really change … the whole group facilitation portion is probably obsolete. It's not based on the learner; it's based on the presenter. So that focus is not going to work. (*December 14, 2012; Quote #7*)

According to Sandy:

> This approach would be "gems" for our kids as the presenter would connect to the learner. If each workshop could make the connection with some traditional knowledge somewhere along the way, "this is the traditional knowledge and the way this was done, and this is the modern science." It's really good and very important to show the cultural connections and it doesn't take a lot … it just means honoring it. Just honoring the traditional law and establishing a connection point, and then you've got it, that's relevance. (*December 14, 2012; Quote #8*)

The above concerns are directly linked to personalizing learning and honoring traditional knowledge. Sandy continues:

> … one of my interests is looking at how we are honoring traditional knowledge and preferred learning styles, and where it connects with research around 21st century learning. So, you are talking about honoring the traditional knowledge base, you're honoring the learner, you're giving the learner the opportunity to select. You're giving the learner the opportunity around all of the layers of choice that a 21st century learner wants. I think that has to change for Aboriginal learners very much, because I think that in terms of learning they've always been in line with what is reflective, socially mediated. That's always been, but you put that in the 21st century context, where that form of learning, is actually much more valued … people are gaining an awareness of that. (*December 14, 2012; Quote #9*)

Sandy reiterated the fact that Aboriginal students in science classes are likely to possess a traditional knowledge system that is different from the conventional science typically taught in schools. This implies that culturally-specific pedagogies need to be adopted in classrooms to support Aboriginal students and their learning strengths.

DISCUSSION

The findings show that there were successes and challenges emanating from the lack of cultural knowledge, including culturally sound pedagogy, cultural/historical approaches, and cultural ways of knowing. These successes and challenges can be categorized as follows: i) increased interest and engagement in scientific activities, ii) gaps/barriers in SOPs' delivery of curriculum, iii) rethinking the structure of SOP's programmatic approach, and iv) responding to the needs of the 21st century Aboriginal learner.

INCREASED INTEREST AND ENGAGEMENT IN SCIENTIFIC ACTIVITIES

The results of this study indicate that generally, the program is successful and effective in terms of presenting science and technology concepts in a hands-on manner that enhances student attitudes towards, and, interest in science. In addition, the students reported that the workshops inspire greater understanding of concepts and expose them to the excitement and enjoyment of scientific discovery (discussed in another paper). Data from the study reveal that participants consistently commented positively on the experiences, including the fact that the workshops (i) engage and inspire students; (ii) provide opportunities for all students to engage with materials and resources that are not readily available in their science classrooms; (iii) make science learning fun and interesting; and (iv) encourage student interest in pursuing careers in science and technology. The notion of relevance and connecting to traditional ways of knowing (Hodson, 1993; Sutherland, 2002) are areas that warrant closer attention in terms of the science workshops. When introducing a topic, workshop presenters may consider storytelling. For example, in the workshop focusing on the body, some probing questions could include: how does the topic at hand link to the use of traditional medicine? or how does cedar tea affect certain parts of the body? Teaching science in Aboriginal contexts require approaching the teaching of science through the students' worlds. This in turn provides students with the opportunity to identify with aspects of science that resonate with their experiences in everyday life. Hence, teachers need to develop subject matter knowledge that is not separated from relevant pedagogical content knowledge in order to change their teaching practices for diverse students (Tal, Krajcik, & Blumenfeld, 2006). For teachers, the workshops (i) exposes them to cutting edge technology, as Don recollected his amazement during a workshop as he witnessed the presenter using a microscope that was hooked up to the SMART Board; (ii) encourages them to try new strategies as they become more confident in their science teaching, exemplified by Doug (Quote #5) as he discusses the value of being able to observe different pedagogical approaches implemented by the workshop leaders and to think of ideas and ways he could implement them in his practice; (iii) provides them with opportunities to observe their students' strengths/learning styles as they engage in science and technology learning; and (iv) enhances their learning of content knowledge. These successes are further captured by Fiona in Quote #4 whereby she emphasizes the importance of teacher involvement in the planning of outreach program activities.

It is extremely important that teachers are involved in the planning of the workshops and knowledgeable about technologies involved in the workshop. As well, it is imperative that these technologies do not conflict with Aboriginal ways of learning and knowing. That is, it is important in this process to establish congruence between Indigenous ways of knowing and new technologies. This is in keeping with the post-colonial theoretical framework that requires educators to refrain from colonial frameworks that reinforce the status quo (Hickling-Hudson & Ahlquist, 2003).

The finding presented are consistent with the research on outreach programs discussed earlier that have broad goals such as providing mentoring and hands-on experiences for students and supporting teachers to enhance their classroom teaching (Knox, Moynihan, & Markowitz, 2003).

GAPS/BARRIER IN SOPS DELIVERY OF CURRICULUM

Despite the above mentioned benefits, participants also mentioned some areas for improvement that would enhance opportunities for successful implementation of the workshops in Aboriginal communities. Some areas where the science outreach program is being encouraged to develop are hands-on/ experiential learning activities, with cultural relevance and context incorporated throughout, so as to honor traditional Aboriginal perspectives and knowledge as exemplified by Aikenhead and Michell (2011) and one of the science educators at Skénnen School, in Quote #8, as she discusses opportunities for the outreach program to incorporate traditional and cultural connections into the workshops.

Additionally, workshops should be designed with more learner control and choice built into the workshops and story-telling and artistic representation to promote student agency as demonstrated by Calabrese-Barton (2005) and Calabrese-Barton and Tan (2010), whereby students see themselves doing science and becoming potential scientists(Hodson, 1998). Aikenhead and Michell (2011), and Cajete (1999) propose numerous ideas for science teachers interested in fostering science classrooms where students can embrace and learn both Indigenous and scientific ways of knowing. Some resources include i) Elder involvement in the classroom, ii) community contexts whereby participation in cultural camps, community gatherings and ceremonies inform the development of science lessons, iii) parents and community members' involvement in planning and evaluating science instruction, and iv) role models and mentors in the classroom.

RETHINKING THE STRUCTURE OF SOP'S PROGRAMMATIC APPROACH

A key finding is the teachers' request for the inclusion and involvement of family members in workshops in their classrooms. This was also echoed by students; however this data is being reported elsewhere. The science outreach program is advised to consider a workshop day for families as this is one approach to building respectful and inclusive relationships with Aboriginal communities (Hunter & Schwab, 2003). In addition, family involvement in workshop development and administration has the potential to encourage student achievement and positive learning outcomes (Hill & Taylor, 2004). One important area in which the science outreach program was advised to further develop is cultural sensitivity or an understanding of the context in which the workshops are situated, including culturally inclusive teaching and instructional strategies. This is reflective of the tenets of the sociocultural theory of learning which assumes a novice/expert interaction where learning occurs mediated by cultural artifacts and tools (Lave & Wenger, 1991; Rogoff, 1998; Roth & Lee, 2004; Vasquez, 2006), and further reiterated by Sandy, the principal, as she discusses the efficacy of the SOP's workshops in terms of "honoring traditional knowledge and preferred learning styles". This was further elaborated upon as she critiqued SOP's pedagogical approach in Quote #7 during her discussion of the lack of differentiation of the workshop material, including focusing on multiple learning styles that is inclusive of a variety of learners, and incorporating technology for meeting the needs of 21st century learners. Finally, workshop leaders should be knowledgeable about the context in which the workshops are conducted. Moreover, as previously mentioned in the section on gaps, cultural sensitivity training should be a mandate for all workshop personnel in order to establish relationships and achieve success with the program in Aboriginal communities. The latter observation cannot be overstated.

RESPONDING TO THE NEEDS OF THE 21ST CENTURY ABORIGINAL LEARNER

Findings point to the fact that further program development is necessary in terms of promoting 21st century skills (DeCoito, 2012). In addition to addressing the needs of 21st century learners, some probing questions that were raised in the interviews included: How much element of choice and how much element of user control can be built into outreach science workshops? How much can they be tweaked, based on 21st century learner needs? The participants expressed the fact that there is a risk that the presenters can become very robotic; hence there is a need to remove the mechanical component and build in learner ownership and learner choice, otherwise, the science workshops can potentially become obsolete. Moreover, there is a danger of the enculturation of Aboriginal learners into the value system of Western science (Aikenhead, 2001), which is explicitly not a goal of the science outreach program in this study. The above concerns are directly linked to personalizing learning and honoring traditional knowledge, including the arts as represented in the Peacemaker mural mentioned in the context section and in Quote #9.

According to Munroe et al. (2013), there exists congruency between Aboriginal knowledges and tenets of 21st century education. Cloud (2010), an advocate of 21st century education, has written about the need to educate for the sustainable future of the planet, with an emphasis on "cultural preservation and transformation, responsible local/global citizenship, sustainable economics, living within ecological/natural laws and principles, multiple perspectives, and a sense of place." This notion that "art and science are modes of perception which are not opposed to each other but complementary and dependent upon one another", is also stressed by Cajete (1999), and in keeping with the guiding principles of two-eyed seeing (Martin, 2012). Activities incorporated in the outreach program that highlight cognitive and cultural conflict (e.g., excessive writing which conflict with oral traditions) and enhance frustration (e.g., reliance on numeracy) should be re-assessed to acknowledge the difference between Aboriginal student's cultural identity and the culture of school science (Aikenhead, 2002). Additionally, the science educators stressed the fact that there is a need for the outreach program to incorporate activities that integrate with existing technology at Skénnen School (e.g., Promethean and SMART Boards) in order to engage diverse learners.

CONCLUSION

In conclusion, how well a program reaches its dissemination goals depends on the interaction of educators and their context with factors related to program designers and their context, to dissemination strategy, and to their audience. Through a post-colonial framework, the study employed sociocultural learning theory which situates learning in social and cultural contexts. This study has shed some light on areas of an outreach program that were successful, and on areas that can be improved in terms of science outreach programs such as SOP. We hope the results of this study will inform future investigations into science teaching and learning in Aboriginal contexts. What holds promise for us is the potential for viewing Western and Indigenous science as having complementary strengths; the guiding principle of *two-eyed seeing*. Recognizing the strengths of each type of science could maximize science learning. This study has attempted to initiate and engage in that dialogue. Much more research in Aboriginal science education is warranted, including Aboriginal youth participation in science, technology, engineering, and mathematics (STEM) education and occupations in STEM fields. Furthermore, resources reflecting Indigenous knowledges in science, technology, engineering, and mathematics should be developed at the Ministry level, as the mandated science and technology curricula in Ontario are largely expressions of the dominant culture, and the intentions of these curricula are not adequately grounded in the priorities of Indigenous communities.

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