Effective STEM Outreach for Indigenous Community Contexts – Getting it Right, One Community at a Time!

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Abstract

Unequal K-12 preparation, lack of mentorship, and cultural isolation in STEM programs pose barriers to post-secondary engagement for many Indigenous students in Saskatchewan (Canada). K-12 STEM outreach aims to encourage future STEM participation among underrepresented cohorts, but the impacts of outreach initiatives depend on the intersections of program design and delivery with community priorities and local learning needs. The University of Saskatchewan Science Ambassador Program uniquely positions outreach staff, 'Science Ambassadors', as two-way learners during placements in remote Northern Indigenous community schools, connecting cultural engagement to the STEM outreach mandate. This paper describes development of the program drawing on program reports (2007-2016), data from post-placement surveys, and reflective practice to identify best approaches and potential barriers to effective STEM outreach in Indigenous community contexts.

Introduction

K-12 outreach is a promising avenue to encourage the participation of underrepresented cohorts in the STEM disciplines–including immigrant, female, and Indigenous[i] students—but the impact of outreach initiatives hinges on effective program design and methods of delivery that resonate with local learning needs (Laursen, Liston, Thiry, & Graf, 2007; Aikenhead, 2012). The wonder-invoking explosions that attract urban children to Science Centre demonstrations can be foreign and othering to students if they cannot connect these to their daily lives or imagined futures (DeCoito & Gitari, 2014); likewise, routine classroom approaches to STEM instruction can alienate youth whose cultural perspectives are not reflected by Western academic tradition (Aikenhead & Michell, 2011).

Recognising the relevance of these complexities to STEM engagement for Indigenous learners in the Canadian prairie provinces, an NSERC[ii] Centres for Research in Youth Science Teaching and Learning (CRYSTAL) research team consulted Indigenous community leaders, Indigenous students, and (largely non-Indigenous) STEM instructors to identify K-12 outreach strategies that would "take into account the lived histories and experiences of individual learners" (Glanfield, Wilson, Rangacharyulu, Cowan, & Mcvittie 2005). Student-teacher relationships, often established through extra-curricular coaching and mentorship, emerged as a key factor motivating STEM engagement in secondary school and laid a

foundation of trust from which instructors could encourage aspiration to post-secondary learning (McVittie & Dunkley, 2008). Indigenous student participants shared an intrinsic enjoyment of STEM subjects with researchers; however, a third of those interviewed "could not think of any way that science applied to their lives" (McVittie & Dunkley, 2008). This disconnect between curricula, daily experience, and cultural realities discourages STEM persistence (McMillan, 2007; Aikenhead & Michell, 2011) and ultimately undermines community resilience, for "without capacity in science and math, an individual or a community is less able to participate in self-governance, less able to make informed choices, [and] less able to match people to necessary careers" (Wilson & McVittie, 2007).

Enhancing the relevance of K-12 STEM curricula is a key recommendation of efforts to improve outcomes for Indigenous graduates (Aikenhead & Elliot, 2010; Voice, Vision & Leadership, 2011; DeCoito & Gitari, 2014) but curricular reform is difficult to enact in communities that have a well-earned distrust of institutional education (cf. Deer, De Jaeger, & Wilkinson, 2015; Truth & Reconciliation Canada, 2015) and where STEM programming may have lower priority than activities that more directly resist assimilation of Indigenous culture, language, traditions, and ways of knowing (Battiste, 2013).

Loss of Indigenous knowledge in "the languages of math (Western symbols) and scientific terminology" is a concern voiced by some Indigenous community educators[iii] (Sterenberg & Hogue, 2011), and many teachers and parents are critical of Western science for perpetuating the twinned ideas that the only knowledge 'worth knowing' comes from white male scientists, and that science is logical, abstract, and unemotional—thus potentially amoral (Wilson & McVittie, 2007). In contrast, Indigenous knowledge systems balance intellectual and physical experiences with spiritual and emotional growth (Battiste, 2013), positioning the learner in relationship with and responsibility to their environment, "the built or natural, other humans or other beings" (Wilson & McVittie, 2007). In the context of relational learning, a teacher is learning in relationship with her students and their environment (Dorion, 2010)—a pedagogical stance far removed from didactic STEM instruction (Aikenhead & Michell, 2011), but resonant with the inquiry-based and exploratory hands-on activities promoted as best practices for K-12 outreach (e.g. Laursen et al., 2007; Sawchyn, 2010; DeCoito & Gitari, 2014).

Goulet & Goulet (2015) share the Woodlands Cree term *kiskiaumatowin* to describe transactional, or 'two-way,' learning, in which teacher and learner approach knowledge through shared interactions, observations, experiences, and mutual exchange. The University of Saskatchewan's (U of S) Science Ambassador Program (SAP) is rooted in *kiskiaumatowin*; it began with the simple premise that by connecting the cultural and pedagogical capacity of Indigenous community schools with post-secondary Science Ambassadors (SAs), shared experiences could foster the relational learning necessary to bridge cultural dissonance, and counter student and teacher attitudes that dismiss STEM learning as difficult, boring, and/or irrelevant (Vassileva, 2011a). This paper describes development of the SAP, drawing on program data collected by the author (SAP Program Coordinator, 2012-2017) over five years to identify promising strategies to promote two-way learning, and "make science fun and relevant, one community at a time!"[iv]

Methods

Program Development

Combining CRYSTAL research outcomes (Glanfield et al., 2005; Rangacharyulu, 2008) with a mandate to increase minority engagement in STEM afforded by a Cameco/NSERC Prairie

Women in Science and Engineering Chair, Computer Science Professor Julita Vassileva piloted the SAP in 2007, partnering SAs with two Indigenous community schools near Saskatoon, Saskatchewan and two in Northern Manitoba. The program rapidly gained momentum and, with industry and government sponsors, has been coordinated through the U of S College of Arts & Science (with broad support from partnering STEM colleges) since 2012 as a priority activity for Indigenous community engagement. By spring 2016, 128 SAP placements had been coordinated across the provinces of Saskatchewan, Manitoba and Alberta, reaching up to 12 communities that vary widely in size, cultural tradition, and instructional capacity each year (Table 1, see p. 28).

SAs include senior undergraduate and graduate students hired competitively from U of S academic and professional colleges on the basis of strong disciplinary backgrounds, demonstrated creativity, and excellent communication skills. Prior experience working with youth, coaching and teaching, and knowledge of Indigenous culture and community priorities are important selection criteria. Though SA positions were advertised in student job postings, word of mouth and the recommendations of prior SAs were the most common prompts to apply cited by students. Roughly equivalent numbers of permanent Canadian and International students, and graduate and undergraduate students, were hired annually, with a male: female ratio approximating 4:5 (SAP Annual Reports, 2012-2016). While every effort was made to hire Indigenous students, $\leq$ 2 were recruited each year, reflecting the underrepresentation of Indigenous students in post-secondary STEM programs.

SAP placements are prioritised for remote schools with few or no specialist STEM instructors, and with a high proportion (40-100%) of Indigenous students. SAs initially concentrated their activities at the grade 4-8 level, formative years for the development of positive attitudes toward STEM learning; however, the SAs' scope of engagement broadened in many communities to include grades 1-12, Kindergarten, and sometimes Adult Basic Education programming at school administrators' requests (Table 1, see p. 28). Travel logistics also impacted the program's evolution. Placements in 2007-2011 varied from a single SA making periodic visits over a school year (within 200 km of Saskatoon), to a pair of SAs residing in a remote community for an extended period (> 3 hours' drive, or fly-in). Continuous placements require community buy-in, with room and board provided by the host school, First Nation administration, or an industry sponsor. This commitment of resources raised administrative expectations, promoted strong student and teacher engagement, and shifted the role of SAs from itinerant 'activity leaders' to a presence in the community, which proved essential to developing authentic learning relationships with students and teachers (cf. McVittie & Dunkley, 2008). From 2012-16, all but one SA placement were continuous, varying from 4-6 weeks in length, scheduled between the end of the academic exam period (late April) and the end of the K-12 school year (mid-June)(Table 1, see p. 28).

While common STEM outreach outcome indicators were identified by Vassileva (e.g., increased student retention, attitudinal changes toward STEM, and toward the role of underrepresented persons in STEM; 2011b), the SAP's stated outcomes reflect the goals of participating communities and include: (1) enhancing science education by empowering teachers; (2) having SAs serve as mentors and role models to younger generations; and (3) creating long-lasting relationships and dialogue between communities and the U of S (Vassileva, 2011a). Beginning in 2009, annual symposia provided a forum for SAs to share their experiences, and for teachers, school administrators, faculty, and program staff to reflect on the program's development and effectiveness. This dialogue led to adoption of two further SAP goals that embrace motivational and aspirational program outcomes: (4) to provide fun

and engaging science experiences to teachers and students in remote communities; and (5) to broaden the pool of future post-secondary STEM students.

Key differences between the SAP and other STEM outreach initiatives in the prairie provinces (reviewed in Aikenhead, 2012) are: the length of student and community engagement; intentional integration of SAs in extra-curricular and community events to support relational learning; and flexible programming tailored to community-specific teaching and learning needs (vs. fixed lesson plans/kits). SAs consult past years' program feedback (when available), and plan and pack materials to align their activities with proficiencies in host schools. During placements, they spend a significant amount of their time planning, revising, and consulting with teachers and establishing points of connection with community educators and youth (Sawchyn, 2010; Table 2, see p. 30). Specific activities vary among schools, depending on the participating grade levels, outdoor weather and accessibility, community events, STEM teaching capacity, and the disciplinary strengths of the SAs. Common activities include delivering demonstrations, activities, and experiments; coaching student projects; coordinating fairs and symposia; facilitating outdoor activities; joining and supporting students at cultural and extra-curricular events; facilitating discussions about 'big ideas' in science, especially those with special relevance to host communities; supporting teacher lesson plans; and tutoring and mentoring students who are exploring possibilities for continuing STEM education and careers (for further detail, see SAP Annual Reports 2012-16).

Results

Program Impact & Assessment

In a small community, two extra young people draw immediate attention, and so do their activities: "*Our population just grew by two and everybody is freaking out!*" (school principal, 2015). Teacher and student pre- and post-surveys collected 2008-2011, and post-surveys collected 2012-2016, demonstrate a positive correlation between hosting SAs and student attitudes toward STEM learning and careers, with $\geq$ 90% of students reporting that they "enjoy hosting SAs" at their school and a majority "excited to study science and math" in high school each year (Vassileva, 2011a; SAP Annual reports, 2012-2016).

Strong positive bias is common in K-12 outreach data, and may reflect enthusiasm for novelty and excitement, rather than deep learning (cf. Laursen et al., 2007). Positive immediate responses are, however, foundational to longer-term impacts (e.g., Bruce , Bruce, Conrad, & Huang, 1997), and Laursen et al. (2007) propose that multi-year outreach programs validly position continued participant demand as an indicator of effectiveness. By this measure, the SAP has been very successful, engaging many communities over multiple years; and, the inclusion of SAs in the planning and delivery of community-wide activities is characteristic of multi-year host communities (Table 1, see p. 28). Teacher surveys report consistent increases in students' confidence and receptivity to STEM learning during and after SA placements, and questions prompting feedback and new activity requests demonstrate a correlation between multi-year SA placements and increased teacher and administrator ambition for STEM engagement in their schools (SAP Annual Reports, 2012-2016; Table 1 & 2, see p. 28 & p.30).[v]

The commitment of resources to hosting SAs requires support from the community at large, and has been sustained by a strong culture of youth advocacy in Northern Saskatchewan and Manitoba. Two-way learning is valued by community hosts, both for the broadening effects on youth who benefit from mentorship with SAs from 'away' and for community-wide

opportunities to discuss the knowledge traditions of Western science within an Indigenous context (SAP Annual Reports, 2012-2016). One community educator reported that the best SA activities were "*sitting around, sharing stories, laughing and respecting our ways and views*." He continued: "…*I think the students now realize that science can and should be learned by anyone and that everything is connected—much like the Aboriginal perspective on things*." This organic bridging of cultural perspectives is facilitated by community hosts who often urge SAs to 'slow down,' learn from the natural environment, and reserve time for reflection and adjustment of their activities during their stay in community. These placements offer unique cross-cultural learning opportunities to SAs, and raise unique needs for programmatic support to prepare STEM students with little prior experience working or living in Indigenous communities for effective two-way learning.

Growing our Science Ambassadors

Assumptions about effective STEM outreach

I came to the SAP in 2012 with some prior experience working in remote communities, but was hired primarily on academic credentials (author; instructor; Ph.D., 2007). I had participated in STEM outreach as a graduate student, mentoring girls interested in STEM, judging science fairs, leading science demonstrations, and making classroom presentations. I was excited to share what I, a non-Indigenous woman with diasporic and Settler roots, loved about my discipline (geobiology), and worked hard to translate challenging topics for diverse audiences. I was encouraged by faculty mentors to present STEM as both a-cultural within itself and as a collaborative mega-project that requires diverse voices to thrive. In my first year as SAP Coordinator I hired SAs and provided program supports based on the past coordinator's recommendations, as well as my own experiences leading 1-2 hour activities in urban classrooms. I was aware of funding inequities that affected STEM teaching capacity in remote Indigenous schools, and attentive to the call to build curricular relevance for Indigenous learners (cf. Voice, Vision & Leadership, 2011), but had little advice to offer other than to encourage SAs to ask for help and feedback from community members (cf. Aikenhead & Michell, 2011).

Learning on the ground

I learned fast on the ground in spring 2012. Monitoring SA activities at a distance and during brief community visits, I began to untangle the mutual influences of community vs. campus-based mentorship on the SAs effectiveness. Most SAs experienced travel North as an adventure and shared stories of warm welcomes as they connected with youth, teachers, and broader community. They learned new words in Michif, Nehiyaw/Cree, and/or Dene, and were invited to participate in sports, fishing derbies, canoe trips, church activities, cultural celebrations, crafting circles, and sometimes cultural ceremonies. I had anticipated supporting SAs with STEM content knowledge and lesson delivery, but during weekly check-ins found myself much more commonly serving the role of an interpretive sounding board for the SAs' rapid, reflective, cross-cultural learning.

School administrators were receptive to the STEM activities SAs organised, calling them "*fun*" and "*exciting*" and "*a big help*" to teachers. They were appreciative that their students were connecting with academic role models and building positive relationships with people from other places and cultural backgrounds. Administrators also related classroom and community missteps (usually with good humour and patience) and offered candid advice to both me and the SAs regarding unique socioeconomic, political, and cultural capacities in their schools. These discussions, as well as my own uptake of invitations to attend and participate in cultural celebrations, built my capacity to guide SAs when they encountered

situations that had alternate potential to reinforce or reframe stereotypes held about Indigenous communities (see UAPS-Saskatoon Report, 2011) and, thus, to undermine or support learning relationships with Indigenous students and teachers.

As an example, one pair of SAs were indignant that teachers left their classrooms to prepare snacks. They had not experienced the challenge of learning while hungry, and failed to identify a link between providing snacks and helping children to focus and participate in curricular activities. In another instance, SAs were amused that string and glue were "*stolen*" from their activity bin, and then "*obviously*" used for crafts in another classroom. With limited awareness of funding deficits in Northern schools and the challenges to classroom supply in a fly-in community, they had little empathy for a teacher who coveted their 24L bin of activity materials. Other SAs encountered overt bias between Indigenous and non-Indigenous members of their host community when emotions flared in the wake of a naturally occurring forest fire, and were confused by contradictory stories that challenged many of their own preconceptions.

SAs were surprised at the magnitude of socioeconomic disparity they encountered in host communities, and by differences in teaching capacity and student supports between urban and Northern schools (cf. Aikenhead, 2012). Many were humbled by their ignorance of Indigenous language, culture, history, and community priorities. Encounters with bears, moose, dogs, and even mice were novel for many SAs, and faced with unfamiliar social and classroom expectations, and the stresses of living and working with newly acquainted SA partners, many required reminders to work from their areas of strength, to build on the momentum of small successes, to join recreational activities, and to ask for and accept the willingly offered support of local teachers and community hosts. Community advocacy is key to the on-the-ground effectiveness of the SAP program, and to the SA experience—despite initial challenges, between 2012 and 2016 only two SAs who remained eligible (held student status) indicated that they would not consider returning to the program, while all participating SAs indicated that "*Yes*" they would recommend the program to another U of S student.

Iterative expansion of SA preparation & support

SAs were asked to complete post-engagement questionnaires reporting details on their activities, program recommendations (also requested from teacher and administrative surveys), and reflections on their own learning experience. From 2012-16, 81 SAs returned completed questionnaires to the Program Coordinator during debriefing interviews. All SAs consented to the use of questionnaire data for annual reporting and program development, and ethics approval was obtained to pool responses as secondary data for analysis and discussion. Five specific questions prompted the SA perspectives shared in this paper (re-ordered here):

A. Is there a topic or subject that you think would be a useful focus of future professional development sessions for new Science Ambassadors?
B. How has the placement changed your perceptions of education available to students in rural [Indigenous] community schools?
C. Were you able to establish rapport with the students? Please explain why and how (connection points), or why not (obstacles).
D. Did you feel supported in your work by the broader community? Please explain.
E. How has being a Science Ambassador affected your perceptions of science, and your goals as a student and pre-professional?

Responses to these questions were randomised across annual datasets, then categorised to identify common emergent themes relating to SA's engagement in relational learning, uptake

of program resources, and self-identified and cryptic knowledge deficits, as well as independently developed engagement strategies and personal outcomes (cf. Creswell, 2007). This analysis does not attempt objectivity, but is action- and activity-focused and informed by the Program Coordinator/author's experience, methodological *praxis*, and cyclical evaluation of data against theories of relational and Indigenous pedagogy (cf. Cordiero, Baldini Soares, & Rittenmeyer. 2016).

Self-identified knowledge deficits

Question A provided SAs the opportunity to suggest professional development topics for future delivery. Responses included requests for support developing hands-on STEM teaching strategies (17% of responses) and teamwork skills (10%); however, most SAs requests related to learning about the culture of the schools (19%), and the environmental (17%), and historical and contemporary cultural contexts of host communities (19%)—background information that would increase SAs' confidence and sense of safety engaging in the dialogue required for two-way STEM learning (19%)(Table 3; top, see p. 31). These self-identified SA deficits were addressed through the addition of new program resources, including a closed Facebook discussion forum to share advice between past and current SAs, the addition of trouble-shooting scenarios to a program manual, an iteratively developed WIKI database of 'hit activities' indexed to grade level, and orientation to provincial STEM curricula and contemporary issues affecting host schools and communities (Table 3; middle see p. 31). Collectively, these resources decreased the preparatory burden for SAs, increasing their time available in community for dialogue, reflection and adjustment of activities, and relationship building.

Program coordination interventions, including a pre-placement survey for school staff, facilitated pre-placement teleconferences and meetings between SAs and host teachers, and weekly SA check-ins, enhanced my capacity to support administrative problem-solving and advocate for SA's during community placements (Table 3; middle, see p. 31), with fewer requests for orientation to school culture or environmental concerns in multi-year host communities between 2012 and 2016.

We are fortunate to have access to expertise in Indigenous and cross cultural education at the U of S, and a major program development 2013-forward has been to facilitate SA attendance at five workshop sessions each spring, with focus balanced between SA-identified areas of development and support. SAP workshops have included orientation to the physiological and psychological safety that must be met to open space for learning and teamwork (Dr. Sheryl Mills); cross-cultural and multi-vocal STEM pedagogies (Dr. Glen Aikenhead & Dr. Sandy Bonny); Indigenous history and legacies of Indigenous education in Saskatchewan (Sylvia McAdam [Saysewahum] & Colleen Charles); Indigenous Science and Ways of Knowing (Dr. Jeff Baker); and various hands-on activity and engineering design challenge strategies (multiple facilitators, Table 3; middle, see p. 31). Concurrent academic demands (final exam season) affected SA attendance at these workshops, with approximately 2/3 of SAs joining each session and each SA attending approximately 3-5 workshops each spring. Interestingly, returning SAs (~ 5 per year) had strong attendance at professional development sessions, and their perspectives and experiences promoted open discussion. This was helpful, because the anticipated learning outcomes and rationale of each session were not necessarily evident to new SAs until they had experienced the discomfort of a preparation gap (Table 3; bottom, see p. 31).

A "*How to Host Your Science Ambassador*" guide was also prepared for participating school staff based on administrative feedback, including helpful points of orientation in the school

(make sure your SA knows where to eat lunch, find coffee, etc.) and community (social activities, stores, etc.). While developing teacher STEM confidence is one goal of the SAP, and of many STEM-outreach initiatives, in practice teachers often defer to outreach staff and take a passive classroom role (e.g. Goebel, Umoja, & DeHaan, 2009). This contrasts with community-engaged activities where ongoing participation is socially expected—and the SAP's positing teachers as social and cultural liaisons to SAs generates increased opportunities for disciplinary exchange (pedagogic and STEM-focused).

Cryptic knowledge gaps

The intent of SA developmental programming and supports is to provide foundational information to SAs to empower them to better relate to students and teachers, and to interpret their experiences with less reference to stereotypes (Table 3; bottom, see p. 31). However, it is impossible to teach SAs what can only truly be learned from engagement with their host communities; one SA's response to Question A was, "*teaching is more like learning—we also have to prepare ourselves to learn from them. I don't know how to tell that before, though!*"

Responses to questions B-E were candid, and some SAs readily admitted ignorance of unequal educational opportunities in advance of their placements (8 of 81 respondents), while others admitted to having held pejorative stereotypes in explanation for lacking STEM capacity in Indigenous schools: e.g. "*only teachers who couldn't get better jobs,*" i.e. bad teachers, worked there (5/81); or community support for education is low because "*they don't care*" (7/81). From 2012-16, six SAs (of 97 positions offered) withdrew before their placements based on personal fears (and/or pressure from parents or partners) related to forest fires, dangerous animals, isolation, drinking water quality, Internet reliability, and/or around their capacity to navigate social manifestations of substance abuse and poverty. International students are oriented to these concerns quickly, if not in advance of applying, then when they share their plans with Canadian classmates raised in a milieu of pervasive stereotypes about Indigenous people and cultures (UAPS-Saskatoon Report, 2011). The students who apply to the SAP may be motivated by an instinct to connect and help in spite of holding stereotypes. Many have extensive experience working with youth as camp leaders, coaches, tutors, etc., and many have traveled and experienced new cultural contexts. Few SAs, however, have experience with a K-12 educational culture different from their own, and many initially identify pedagogic differences in Indigenous schools as deficits (true of both Canadian and International SAs).

Key self-identified shifts in SA attitudes that emerged from post-placement questionnaires, as reflected in responses to questions B-E include:

- respectful curiosity toward Indigenous knowledge and land-based activities (52/81),
- appreciation for the dedication and unique skillsets of community educators (47/81),
- appreciation of the unique social role of STEM and of STEM professionals (37/81),
- respect for the depth of youth advocacy in Indigenous communities (35/81),
- and new (or deeper) awareness of the impacts of colonial legacies, including First Nations band politics and federal vs. provincial funding structures, on school culture and STEM teaching capacity (12/81).

These positive outcomes reveal preparation gaps, some of which correlate to ignorance of Indigenous community realities and/or to stereotypes. For example, appreciation for the

quality of teaching in a host school may contrast with low prior expectations about teacher competence. One SA shared a prior expectation that Indigenous families "*let their kids run wild*," and was surprised to find that while kids acted up at school, "*out of school the kids are better and calm, and treat adults in their community with respect*." This realization shifted his interpretation of factors affecting student school engagement, and he decided to share advice about post-secondary programs on the sports field where the students were better prepared to listen. Another SA arrived prepared to "*fill a gap*" and discovered that students had already experienced many of her planned activities (e.g., Mentos in Diet Coke explosions, sprouting seeds), while she had experienced few of theirs:

> *I went to a teacher's house for supper. I learned to enjoy their dogs. I went to cultural camp with a teacher and spent quality time with her family. They taught me to steam a caribou head, and shooting arrows. The same Elder then came and brought fish for dissection in our biology lesson at the school.*

Culture camps and festivals in many communities act as forums for discussion of Indigenous perspectives on STEM, and offer spaces for SAs to experience and observe relational pedagogies *in situ*. One SA noted, "*I have now seen many methods of teaching all done in different environments from culture camps to science labs. I have new tools, and I am thinking outside the box!*"

Strategies and barriers to student engagement

In some host communities, cultural engagement is less traditionally focused. SAs have been involved in painting faces at school events, sharing baking, and helping with track and field activities. One SA pair taught students about asphalt physics (the community was about to receive its first paved road) by baking chewy cookies. Another SA pair found points of connection in popular culture after youth requested "*magic*" demonstrations, and asked questions about aliens and UFOs. These SAs developed demonstrations and activities based on flame spectrophotometry, burned Mg^{2+} salts as a demonstration, and introduced the Fermi Paradox and Drake Equation to a grade five classroom whose teacher described them as "*enraptured.*" One SA reflected that he had not previously thought that kids in a remote Indigenous community would be so curious, capable, and excited to learn science–returning from his SA placement, he now "*saw himself in them*," and stated a commitment, "*as a future professional, to make my field and future workplaces inclusive and accessible for people with different backgrounds*."

Many SAs reflected on barriers to STEM learning that they had not previously considered. For example, some schools have excellent lab ware or environmental monitoring equipment in a storage room, but no teacher with training to use them. SAs were able to coach teachers on the use of equipment, building lasting capacity in some classrooms. In other communities mistrust of temporary teaching staff, imminent administrative changes, or unstable teaching assignments undermined teacher-student relationships and affected students' openness to learning. One SA, who had not previously considered his educational experience privileged, conceded "*it is much easier to pursue a science career if you're from the city*." In nearly every community, it was SA extra-curricular engagement that laid a foundation for participation in STEM activities delivered in classroom spaces. As one school administrator shared, the SAs "*were not strangers in any means – making things easy for themselves, the school, and the community*." He added, emphasising the power of relationship to successful STEM teaching, "*we would love to have the same SAs next year*."

Science ambassador outcomes

As Program Coordinator, it was very rewarding to see SAs return from their placements with new confidence and curiosity each year. As university STEM students they were continuously learning new material, and being assessed, and holding themselves to critical standards. As SAs they came to realise just how much they knew (about STEM) compared to the general population. The opportunity to share their enthusiasms, interpret everyday science, and participate in non-competitive community learning was strongly valued, and often served to renew the SAs' enthusiasm and sense of purpose for their studies. An International SA's comment summarises the experience of many:

> *Before I came to [this community] I would think science is just textbook-based knowledge, but after I started my work I realised science is a part of our life. We can 'enjoy' it anytime, anywhere, even in the bush. I'm an engineering student. We realize what our goals are. This SA program made me experience new goals about the way other people learn science, and some of them can inspire and spark me as well!*

Learning Indigenous cultural perspectives is formative for many SAs. Some have become advocates for Indigenous rights and education (e.g. Datta, 2016; Bentham, 2016; Tang & Moleski, 2017) or are inspired to participate in urban STEM outreach and youth engagement initiatives that run through the academic term. For many SAs (50/81), experiencing the cultural strengths of host schools motivates them to learn more about their own backgrounds and goals for STEM participation, for example:

> *This experience has broadened my understanding of the particular ways that current provincial schooling… translates into problems for students, parents and teachers. I feel that I have grown in knowledge of Aboriginal history and current affairs (successes and challenges) as an SA, but also as a person—I feel more connected and committed to understanding my own values*.

For others (35/81) the excitement of youth and enthusiasm of community mentors provide affirmation for their choice of discipline and consolidates their identity as a Scientist or Educator: "*The SA experience teaches you about how science impacts the lives of others, its perspective within other communities, its availability to others, etc. It also reminded me just how cool science is!*"

Preparing for two-way learning and reflective practice

Scientists and students who participate in STEM outreach activities are overwhelmingly motivated by a duty to share what they know with groups who they believe have a knowledge deficit (Verner, 2014). Deficit models of outreach emphasize the responsibility of the instructor and lesson designer, who "simplify, sensationalize, and strategically construct" content to avoid misinterpretation and maintain quality control. Or, as Verner (2014) critiques, to enforce a kind of ontological control that abstracts science in order to avoid engaging with an Other's "worlds of knowledge and experience".

From the perspective of relational Indigenous pedagogy, one-way approaches to STEM outreach impede a learner's ability to take responsibility for the creation of meaning through relationship (Sutherland & Henning, 2009) and risk perpetuating colonial power dynamics, especially if the lessons or activities include de-contextualised Indigenous content (cf. Bonny & Berkes, 2008; Aikenhead & Michell, 2011) and/or examples foreign to the students' life experiences and self-beliefs (Baydala, Rasmussen, Birch, Sherman, & Wikman, 2009). As Bang & Medin (2010) remind us, Culture and Science are both stereotyped by school

curricula, and when they are reflected abstractly the scope of engagement available to students who choose to study either knowledge tradition is compromised.

Aikenhead & Michell (2011) analyse the challenges of bridging Indigenous and Western scientific ways of knowing in central Canadian contexts and highlight the promise of multi-vocal learning resources that braid cultural traditions to advantage the prior learning and strengths of Indigenous students in STEM classrooms (e.g. Aikenhead, 2002). While culturally segregated science curricula may limit students' sense of connection to the broader activities of multi-cultural science (Sterenberg & Hogue, 2011), multi-vocal resources encourage students to adopt the strengths of each knowledge system while engaging in critical perspective taking within the world(s) of science (Aikenhead & Michell, 2011; Sterenberg & Hogue, 2011). McMillan (2007) similarly describes a Both-ways model of teaching, exemplified in resources that blend Western science with narratives that convey *Inuit Qaujimajatuqangit* (traditional ways of knowing), whose adoption by Nunavut schools has encouraged both student and community educator engagement with STEM.

A challenge to these multi-vocal resources is that Indigenous knowledges are place-based, whereas Western science privileges abstracted knowledge. Saskatchewan has a diverse Indigenous population with distinct language groups, regional geographies, and traditions of knowledge transmission, pedagogy, and community governance. Generalist teachers, who make up much of the teaching complement in Canadian schools, may interpret Western Scientific perspectives as universally true, and Indigenous perspectives as idiosyncratic to both place and the person sharing the knowledge (Anuik & Gillies, 2012; Battiste, 2013). This imbalance can perpetuate colonisation of Indigenous perspectives in static resources, especially when knowledge shared by Elders in one community is carried, out of cultural and linguistic context, to another (cf. Sutherland & Henning, 2009). Indigenous pedagogies emphasize the transmission of knowledge not through media, but through enacted processes rooted in relational engagement (Goulet & Goulet, 2015).

During SAP placements, interweaving of Indigenous and Western scientific perspectives, languages, and pedagogies is made possible by relational learning in a community context. The inclusion of SAs in community allows them to connect distinct ways of learning and describing the world and to model this process for students. Shared experiences also allow SAs, students and community members to identify fundamental congruencies between the Western scientific traditions and Indigenous ways of knowing, which include common values of honesty, perseverance, experimentation, curiosity, and aesthetic appreciation (Aikenhead & Michell, 2011). The inclusion of community educators in SA activities beyond the school helps to "make the unfamiliar familiar" for students (cf. Sutherland & Henning, 2009), and "sends a strong signal that science is not just for other people" (cf. Bang & Medin, 2010).

Interacting with students in community also allows SAs a view on students' unique social and cultural capacities, which may be key to challenging deficit views that might be reinforced if interactions were limited to classroom spaces. Gee (2001) highlights how prospective STEM students benefit from opportunities to try out "projected identities"; wearing lab coats, using microscopes, and other "real" activities encourage students to consider the possibility of "self as scientist". Likewise, engaging in inquiry activities, gaining confidence with disciplinary vocabulary, entering peer-level dialogue with SAs, and positioning themselves alongside SAs as peer-leaders to younger grades allows senior students in host schools to try on the role of University Student (Sawchyn, 2010). Time spent with SAs year after year can act as an "anchoring experience" that can be referred to and discussed by students as they explore potential post-secondary identities (cf. Luehmann and

Markowitz, 2007).

It is a commonly held bias that the effectiveness of STEM outreach initiatives "depends on an explicit definition of goals" with assessment tailored to measure goal achievement (e.g. Verner, 2014). It is equally important that achievement of goals, which may be set by external-stakeholders, not overpower the priorities of participants; the SAP has succeed in large part because of commitment to goals derived through community consultation (Glanfield et al., 2005) that were integral to program design (Vassileva, 2011a) and maintained through continued program development (SAP Annual Reports, 2012-2016). Enacting effective two-way learning requires sustained engagement, and from a program coordination standpoint, requires examining, and preparing SAs from diverse backgrounds to examine, existing attitudes, beliefs, and values that will affect their ability to learn with and from Indigenous students (cf. Lehr, McCallie, Davies, Caron, Gammon, & Duensing, 2007); alongside support with logistics of travel, planning, activity selection, teaching skills, and developing resilient attitudes when things don't go as planned (cf. Laursen et al., 2007).

SAs themselves identified knowledge gaps related to environmental and cultural awareness, school culture, teamwork, teaching strategies, and Indigenous perspectives on science as key influences on the effectiveness of their activities. These soft skills are increasingly promoted for STEM outreach and science faculty training to facilitate public communication. Verner (2014) identifies "active engagement, dialogue, and discussion" as crucial to promoting STEM enthusiasm and career engagement, and suggests that STEM outreach training should focus on building confidence to promote dialogue, rather than "strategically crafting messages or activities." Through iterative development of SAP supports and workshops, I have come to value prompting *praxis*—reflection on the relationship between intent, knowledge, and activity—as key to supporting SAs in the community, and as they consolidate their experiences. Prompted reflection questions in post-engagement surveys and debriefing interviews allow SAs—and their Program Coordinator—dedicated space to admit changes in perspective, renegotiate prior assumptions, and to own their experiences as "important enough" to be personally transformative and to motivate continued program development (cf. Smith & Eaton, 2012; Tang & Moleski, 2017).

Conclusion

In academic contexts, preparation to learn is both an independent and collective responsibility, grounded in reflection on the intersections of experience, data, theory, and wisdom within our communities of practice—a process of active *praxis*. Indigenous learning journeys also begin with preparation to learn. As Dorion (2010) explains, effective students and teachers prepare themselves by developing a quality expressed in the Nehiyaw / Cree word *kiskinwahasimowewin*, the ability to "ask for, receive and accept guidance" from human and other-than-human teachers, a learning spirit that is a gift to each of us. The SAP has grown with continued input from host schools, whose expectations and active contributions shape the role, activities, and experience of SAs in their communities, and the depth of STEM learning and mentorship experienced by their students. Honouring the program goal voiced by community educators to create long-lasting relationships and dialogue (Vassileva, 2011a) has been key to the program's continuity and transformative impact.

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Table 1: Science Ambassador Host Communities, 2007-2017.

Year(s)	Location	Pop*	Language	School Admin	Grades engaged	Travel	Distance rel. to Saskatoon (kms)	Placement Type	Special Activities
2007	Muskoday First Nation, SK	650	English / Cree/ Saulteaux	Federal, Band-directed	4-8	drive-in	155	weekly	
2007-08, 16	Beardy's & Okemasis First Nation, SK	1150	English / Cree	Federal, Band-directed	4-8	drive-in	86	weekly	
2008-17	The Pas, MB	5500	English / French / Michif	Provincial	4-8 & 10	drive-in	570	continuous	Pike Lake Culture Days
2008-17	Opaskwayak Cree Nation, MB	3200	Cree / English	Federal, Band-directed	4-8	drive-in	570	continuous	Pike Lake Culture Days
2009-10	Muscowpetung First Nation, SK	300	English / Saulteaux	Federal, Band-directed	K-6	drive-in	327	week at a time	
2009-17	Hatchet Lake Band/ Wollaston Lake, SK	1750	Dene / English	Federal, Band-directed	K-12 & ABE	fly-in	722	continuous	Mother's Day Festival; Fishing Derby
2010-17	Black Lake Denesuline Nation, SK	1070	Dene / English	Federal, Band-directed	K-12 & ABE	fly-in	801	continuous	Culture Camp
2010-17	Fond du Lac Dene Nation, SK	801	Dene / English	Federal, Band-directed	K-12	fly-in	820	continuous	Culture Camp
2010	Blood Tribe Reserve, AB	4200	Blackfoot / English	Federal, Band-directed	K-12	drive-in	690	continuous	
2011	Mistawasis First Nation, SK	1036	English / Cree	Federal, Band-directed	K-12	drive-in	106	weekly	
2011-15	Flin Flon, SK/MB	5000	English / French	Provincial	4-9	drive-in	530	continuous	
2012-17	Stony Rapids, SK	250	English / Dene	Provincial	K-9	fly-in	818	continuous	Culture Camp
2013-17	Green Lake, SK	500	English / Michif	Provincial	K-9	drive-in	350	continuous	Green Lake Culture Days; Canoe Trip
2013-17	Beauval, SK	806	English / Michif	Provincial	K-12	drive-in	408	continuous	Culture Days; Fishing Derby
2013-17	Pinehouse Lake, SK	1076	English / Cree	Provincial	K-12	drive-in	515	continuous	Elders' Gathering; Sports Meet
2015-17	Satikawak - Île à la	1340	English/ Michif	Independent	K-12 & ABE	drive-in	477	continuous	Culture Camp; Michif

	Crosse, SK								Language Festival
2015-17	Cumberland House, SK	1400	English / Cree / Michif	Provincial	K-12	drive-in	448	continuous	Canoe Trip
2016-17	Buffalo Narrows, SK	1081	English / Michif	Provincial	K-12	drive-in	504	continuous	School Science Fair; trip to sand dunes

Notes: *2011 Canadian census data; [+]K=kindergarten, ABE=adult basic education programming.

Table 2. Average of Science Ambassador Pairs' Estimated Percent Division of Time between Key Activities During Community Placements, April-June, 2016.

			% Division of Science Ambassador's time between STEM outreach activities										
location	**# students**	**# teachers**	***planning with teachers***	***independent planning***	***extracurr. activities***	***classroom demos***	***indoor STEM activities***	***outdoor STEM activities***	***tutoring students***	***helping deliver teachers' lessons***	***project / event facilitation***	***career / student life talks***	***community / cultural engagement***
Sakitawak	200	13	2	25	2	15	20	20		5	2	2	7
Pinehouse Lake	459	22	5	5	5	2	18	10	5		20	10	20
Beauval	220	15	10	10	2	5	30	10	5	10	5	10	10
Buffalo Narrows	180	13	5	20	2	29	20	15		10	20	3	3 *
Green Lake	90	8	1	30	20	4	30	5		4			6
Stony Rapids	65	5	2	2	6	20	50	5	2	2	2	2	7
Cumberland House	60	12	10	10	10	10	10				40		10
Wollaston Lake	225	22		40	5	10	15	10	5			5	15
Black Lake	400	25	10			30	20		20				20
Beardy's & Okemasis	131	9	10	10		60		15					5
Opasqwayak Cree Nation	300	16	10	10		40	30						10
The Pas	100	12	1	10		40	40	2				2	5

*** = Science Ambassadors' report(s) exceeded 100%.**

Table 3: Top: Science Ambassador Suggestions for Useful Contributions to Future Year's Opportunities for Professional Development. Middle: Program Elements Designs to Support SAs in Achieving Developmental Skills and Awarenesses Identified as Important to Effective Two-Way STEM Engagement by Former SAs and Participating Host Schools and Communities (with Professional Development Workshops in Bold). *Indigenous Achievement Week is hosted each February-March and includes a variety of events held at U of S over a five day period. SAs are encouraged to attend open sessions that celebrate cultural perspectives, as well as sessions tailored toward STEM engagement. Bottom: SA learning goals and anticipated outcomes of resources, interventions and professional development opportunities.

Q: "Is there a topic or subject that you think would be a useful focus of future professional development sessions for new Science Ambassadors?"					
Team Skills (0.1)	**Environmental Confidence (0.17)**	**Cultural Confidence (0.19)**	**School Culture (0.19)**	**Teaching Strategies (0.17)**	**Disciplinary Knowledge (0.19)**
how to identify & work with SA partners' strengths	safety during outdoor activities (around boats, on lake ice, near fire, etc.)	Aboriginal history 101	balancing teacher requests / scheduling time between classrooms	timing of lessons & activities	how science & culture intersect
how to make sure each SA contributes to planning & delivery	how to ship materials, receive & send mail, cash cheques, etc.	what is an Elder, knowledge keeper, trapper, chief & councilor, etc.	classroom management / setting expectations for behaviour & participation	adapting activities to different grade levels	the scientific method vs. the engineering design cycle
more dialogue between SAs across communities	dog & wild animal safety (mice, bears, deer, etc.)	cultural protocols: e.g. how to ask an Elder to join activities, how to ask for help	where STEM fits in school priorities	accommodating students with disabilities	how to teach scientific vocabulary
	where to get groceries & how much they might cost	how to 'go with the flow' / what is normative behaviour in the community	us vs them mentality between teachers & students, or teachers & community	what STEM materials are in the school already vs. what to bring up	more about Indigenous science
	boundaries with students outside of the school	socioeconomic context of host community	working around student attendance issues & engaging difficult students	Indigenous pedagogies	some areas of science most relevant to the community

	what to do on the weekend or in the evening		what did the SAs do last year?	how to know if the students are learning vs. "just" having fun?	more about the courses & the expectations in the high school curriculum
Resources, Interventions & Professional Development Opportunities					
Workshop: A Learner's Needs / Maslow's hierarchy & Glasser's Choice theory (S. Mills)	Program Coordinator proactively question during weekly check-ins	promote Indigenous Achievement Week events (on campus)*	**Workshop: Contemporary issues - e.g. Band Educational Newsletters, school websites**	**Workshop: Multi-vocal STEM Activities, SK Cradleboard Initiative (S. Bonny)**	**Workshop: Bridging Cultures in Science Classrooms (G. Aikenhead)**
Workshop: Effective Team Design Challenges (S. Bonny)	"Hosting SAs" guide prepared for schools	**Workshop: Legacies of Aboriginal Education in Saskatchewan (S. McAdam)**	Activities WIKI developed 2012-2016 with 'hit activities' indexed to curricular topics & grade level	**Workshop: Integrating Maths into Hands-on Activities (S. Stavrou)**	review of STEM Education course progression & standards in SK
closed Facebook discussion forum	monitor SA communication with schools in advance of placements	meet for coffee or connect online with past year's SAs from host community	**Workshop: Northern Community Engagement, strategies & perspectives (G. Sibley)**	**Instructional Workshops: e.g. Hands-on Science show 'n tell (L. Elias); Teaching Earth Science (K. Grapes-Yeo); Agriculture in the Classroom Seeds 'n Sprouts (S. Jorgensen); Learning 4 Fun Indicator Rubrics (S. Bonny)**	team review of K-8 Provincial Science Curriculum - online & condensed cheat sheet
trouble-shooting scenarios (co-habiting, co-teaching & time management) in Program Manual	roundtable discussion with past years' SAs	post-placement surveys, individual & group debriefs & symposium presentations	pre-placement teacher request survey distributed by administrators		**Workshop: Indigenous Perspectives on Science (J. Baker)**
Goals / Anticipated Outcomes					
increased empathy during new experiences	tips to school to help them provide practical support to SAs in their community	foundational historical & cultural contexts of Indigenous education	share contemporary realities & community priorities for youth	brainstorm creative approaches to delivery of STEM curricula	reflect on cultures of science
experience working as a team, negotiating roles	reduce fear of animal & fire encounters with practical advice	learn from Indigenous scholars, students & cultural leaders in advance of SA training	advice for working 'with' vs. 'in' the community	integrate math literacy with hands-on and computer activities	identify cultural influences in one's own "STEM Thinking"

increased communication; reduced sense of isolation during placements	reinforce the SA role as a STEM outreach instructor, not a peer or social worker	help SAs recognize cultural positions, & how to help students bridge perspectives	ensure that SAs are asking the questions they need to prepare	co-create a rubric to guide reflection during placements & identify when students are demonstrating enjoyment, engagement, learning, & inquiry behaviours	brainstorm culturally-relevant methods of teaching & delivery
normalise challenges, provide practical solutions	problem-solving support & advocacy for SAs during placements	prompt reflection & informed interpretation of SA experiences in host communities	decrease preparatory guessing for SAs & increase effectiveness of activities (discourage unvetted activities found on YouTube)		increase SA's confidence speaking to & from cultural positions

Endnotes

[i] In this paper, the term *Indigenous* includes geographically distinct pre-colonial inhabitants of territories around the world. In Canada, Indigenous peoples include members of diverse First Nations, Inuit and Métis communities, who are collectively described by the term Aboriginal in the Canadian constitution and legislative documents, as well as non-status individuals with Indigenous heritage.

[ii] National Science & Engineering Research Council of Canada, Government of Canada.

[iii] The term *Community Educator* is used to include teachers who hold membership in an Indigenous community, as well as Indigenous cultural guides and leaders who may hold the status of Elder, knowledge keeper, traditional land-user, artisan, or social organizer.

[iv] *Making Science Fun & Relevant, One Community at a Time!* is a motto used by the program to acknowledge that the activities involved in making science fun and relevant vary among participant communities, reflecting diverse perspectives on and priorities for STEM learning.

[v] While teacher and administrator feedback was requested via program surveys and interviews (i.e. anecdotally) between 2009 and 2016, quantitative metrics for student STEM outcomes (attendance data, persistence in high school course offerings, grades) have not been possible to collect for reasons including protection of student privacy in small school cohorts and nonstandard data collection across participating educational authorities.