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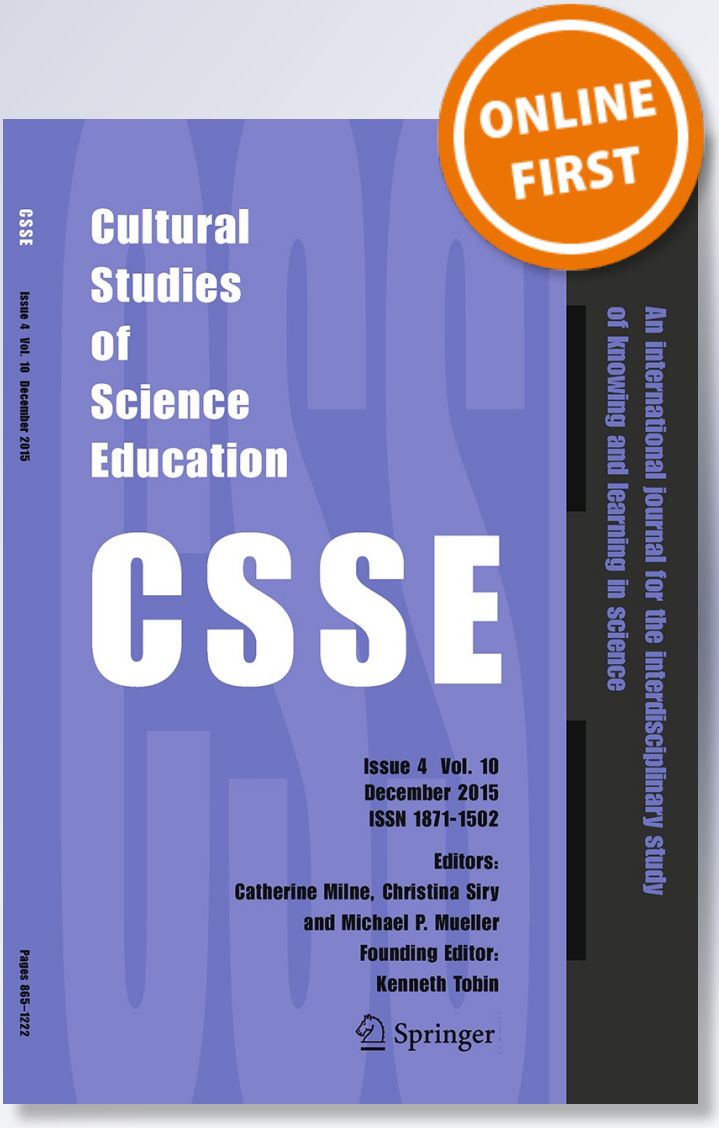

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ORIGINAL PAPER

A cross-case analysis of three Native Science Field Centers

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Abstract Native Science Field Centers (NSFCs) were created to engage youth and adults in environmental science activities through the integration of traditional Native ways of knowing (understanding about the natural world based on centuries of observation including philosophy, worldview, cosmology, and belief systems of Indigenous peoples), Native languages, and Western science concepts. This paper focuses on the Blackfeet Native Science Field Center, the Lakota Native Science Field Center, and the Wind River Native Science Field Center. One of the long-term, overarching goals of these NSFCs was to stimulate the interest of Native American students in ways that encouraged them to pursue academic and career paths in science, technology, engineering, and mathematics (STEM) fields. A great deal can be learned from the experiences of the NSFCs in terms of effective educational strategies, as well as advantages and challenges in blending Native ways of knowing and Western scientific knowledge in an informal science education setting. Hopa Mountain—a Bozeman, Montana-based nonprofit—partnered with the Blackfeet Community College on the Blackfeet Reservation, Fremont County School District #21 on the Wind River Reservation, and Oglala Lakota College on the Pine Ridge Reservation to cooperatively establish the Native Science Field Centers. This paper presents a profile of each NSFC and highlights their program components and accomplishments.

Keywords Informal science education · American Indian youth · Culturally-responsive education · Environmental science education · Indigenous knowledge · Native American languages

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> Whatever you take from here, walk with it, take it on your life journey and carry on these teachings. Keep in mind all of what you are learning. You are learning two cultures, and you are going to walk with those. And our people are going to be strong again, and we are going to work with our white brothers and sisters and teach them what we know.
>
> (Lakota NSFC Community Advisory Board interview with Elder, n.d.)

Forming the Native Science Field Centers

Hopa Mountain—a Bozeman, Montana-based nonprofit—partnered with the Blackfeet Community College on the Blackfeet Reservation, Fremont County School District #21 on the Wind River Reservation, and Oglala Lakota College on the Pine Ridge Reservation to cooperatively establish the Native Science Field Centers. Although the NSFCs continue to build upon the positive impacts described in this case study, they are no longer in operation in the same capacity as described in this article. This is due to transitions in funding sources as well as programming. This paper presents a profile of each NSFC and highlights their program components and accomplishments. Outcome data extracted from an independent case study conducted in 2011–2012 is also included. This research study addressed the following target question: "What are the motivations, interests, and benefits for Native American youth who regularly attend an informal science education program that incorporates traditional knowledge, values and language?"

In the 2011–2012 case study, survey data collected from 69 NSFC seasoned youth participants (those participants involved in two or more seasonal activities and/or involved in the NSFC program for consecutive years) indicated there were significant impacts in three target areas (interest, motivation, and benefits) among participating youth through their involvement in the NSFC program (Valdez 2012). The outcomes show significant growth and influences in participating youth towards engaging in STEM opportunities that are rich with cultural relevancy and apply Native worldviews.

For the purposes of this paper, NSFC programs are examined through a cross-case analysis identifying similarities, differences, themes, and lessons learned that help articulate implications for future NSFC initiatives. It is important to note that while the three NSFCs have several commonalities, they were separate entities (i.e., cases) independent of one another. The cross-case analysis is not intended to be a program comparison per se; rather, it is meant to elucidate the strengths and uniqueness of each program relative to its specific cultural context. Further, this technique captures variations in approaches to program implementation, curricular components, and the degree to which informal science education has been manifested at the community level.

Context and background of the Native Science Field Centers

In the face of social transformation, colonization, displacement and forced assimilation, Indigenous communities persist to maintain their unique worldviews and systems of knowledge associated with them. The survival and ongoing recognition of these knowledge systems has been attributed to an adaptive integrity that carries both intergenerational and cross-cultural value (Barnhardt and Kawagley 2005). As Indigenous knowledge and Western science converge, both Native and non-Native scholars address some of the

complexities rooted in differing worldviews. For example, Indigenous science knowledge is associated with experiential learning and practical applications while Western science is often decontextualized and compartmentalized for a classroom or textbook environment. In relationship to the learner, Indigenous knowledge frequently differs from Eurocentric knowledge systems by acknowledging both the empirical/experience-based and the normative/social values-based qualities simultaneously (Battiste 2002). It has also been noted that traditional Indigenous knowledge is most often distinctively spatially oriented and relational in nature while Western science retains a more temporal and isolated focus (Pierotti and Wildcat 2000). Although these broad patterns between different knowledge systems exist, heterogeneity within Indigenous and Western sciences also justifies recognition and brings unique challenges for cross-cultural understanding (Aikenhead and Ogawa 2007).

Among all of these complexities, one significant characteristic that bears acknowledgement is that Native ways of knowing must also contend with the enduring effects of hundreds of years of imposed Western authority over features of Indigenous knowledge, language and cultural practices (Tuhiwai Smith 1999). In the past, education was a mechanism used to assimilate Native American children in an attempt to change beliefs and values, thus removing culture and identity. Today we realize the historical manifestations of these actions in the severe underrepresentation of Native Americans in STEM fields, both in terms of enrollment as quantified below and in terms of representation of knowledge. Lack of engagement of Indigenous students has been attributed to theoretical differences in producing Western versus Indigenous knowledge, the nature of the instructors and learners, and the inherently colonizing characteristics of the education system (Abrams, Taylor and Guo 2013). Contemporary scholars continue to research and explore the historical and epistemological explanations behind these disparities and recognize the need to better understand the context specific environments that students learn science in (Bang and Medin 2010). To better contextualize our own study we discuss the need for Native Americans in higher education and the STEM fields as well as a model for supporting underrepresented populations through more culturally-responsive science education.

Culturally responsive education to support Native students in science

American Indians/Alaska Natives have historically been underrepresented in higher education. For instance, they represented about 1 % of total enrollment in colleges and universities in 2006 (National Center for Education Statistics 2008). As one might expect when looking at these statistics, Native American enrollment and degree attainment in STEM disciplines remains relatively low, and minority groups remain underrepresented in STEM careers. Demographics indicate that only 11 % of the workforce in STEM occupations includes African Americans, Latinos, and American Indian/Alaska Natives (Chubin, May and Babco 2005). There is a growing need for Native students to complete high school and pursue college degree programs in the STEM fields. Tribal communities need the expertise of Native scientists to (a) help retain tribal languages, cultures, and identities; (b) manage tribal resources; (c) support tribal political and economic development; and (d) work with mainstream institutions. There is also a need to diversify the STEM workforce by creating career opportunities for Native professionals.

Many students may find that learning science in school is like navigating a foreign culture because some cultural interactions and practices are incongruent with their own cultural practice of science. The Western science paradigm often contradicts a student's

cultural orientation. Thus, classroom science instruction may have adverse effects on the student and how they further develop their worldview. Moreover, if left unchecked, this process may have negative effects on a student's self-worth and impede their learning (Aikenhead and Jegede 1999).

Justification for the inclusion of Native American culture and language throughout the curriculum has been made for over 40 years (Senate Special Subcommittee on Indian Education 1969). There is evidence to suggest that integrating students' experiences is necessary for science education to develop cultural relevance (Patchen and Cox-Petersen 2008). Fortunately, the teaching of science in some schools has begun to shift from the conventional Western science pedagogy to one that embraces a multicultural paradigm. All of these ideas combine to form a view of Indigenous science as "a culture-dependent collective rational perceiving of reality" (Ogawa 1995, p. 588).

It is important to realize that, from a cultural stand point, a vast range of perspectives exist in terms of how people organize their natural world and how they define their relationships with other organisms. Many Native communities share broad amounts of scientific knowledge embedded within traditional knowledge with their youth (Brayboy and Castagno 2008). This traditional knowledge and cultural experience influences ways of knowing and can change how youth learn. Gregory Cajete states that "Native science, both in its contemporary and historic sense, is contextual and relational knowledge; it attempts to model traditional ways of teaching, knowing, and understanding these relationships based on the existing makeup of the natural world" (2000, p. 98). Benefits of including Indigenous science in education of Native students and challenges to maintaining culturally appropriate transmission of this knowledge is gaining attention in the academic community. Although there are many gaps in research on the impacts of culturally-responsive education, some studies are identifying guiding principles, including supporting traditional paths for transmitting cultural knowledge both within and outside of the formal school systems (McCarter, Gavin, Baereleo and Love 2014).

Informal science education

In addition to culturally-inclusive approaches in schools, a strong case can be made for extracurricular science education. Having an understanding of how students spend their time out of school is just as important to student academic success as knowing how they spend their time in school (National School Board Association 2005). A solid after-school program can have very positive effects on children's academic, social, and emotional lives—especially for students whose personal circumstances put them at higher risk for school failure (Lauer, Akiba, Wilkerson, Apthorp, Snow and Martin-Glenn 2003). It is apparent that youth who participate in after-school programs have optimistic feelings and attitudes about school, improved social behavior in school, and increased achievement on test scores in school (National Institute on Out-of-School Time 2009).

Informal science education (ISE) involves teaching and learning about science in settings that are outside of the formal school environment. People from diverse backgrounds, interests, and skill levels typically take part in ISE activities for non-academic reasons. Since human beings are "naturally curious, social, and actively engaged in learning, informal science education is characteristically pleasurable, open-ended, equitable, and accessible" (Center for Advancement of Informal Science Education 2013).

There is a need to create learning opportunities that transition students from the classroom to the community. This is especially the case for Native American students who are navigating multiple worldviews between their school and home life. Furthermore, a focus only on the hours that students currently spend in school overlooks the many opportunities for guided learning in other settings. For instance, according to the National Research Council (2000), a student spends 53 % of their time at home and in their community during a calendar year. This is aside from sleeping and time spent learning in a formal setting.

For Indigenous populations, informal science education also provides a forum for integrating traditional knowledge that may not be appropriate for a formal academic setting (Kimmerer 2012). With a history of appropriation, misrepresentation and intellectual property abuses, maintaining the intimate connection between knowledge keepers, the land based context, and the students, remains a critical concern. Informal science education provides a dynamic, adaptive format for addressing these needs while maintaining a culturally appropriate setting. The Native Science Field Centers addressed this need in tribal communities by analyzing opportunities to increase the number of hours of informal guided education to create community learning, leadership and other critical developments that served as the foundation of the NSFC model.

The use of Native American languages

The single most essential component of the development of the NSFC model was the integration of Native American languages. Darrell Kipp, co-founder of the Piegan Institute of the Blackfeet Nation, advises Indigenous communities seeking to revitalize their Native languages to, "use your language as your curriculum—botany, geography, political science, philosophy, history are all embedded in the language" (2000, p. 1). Maintaining the inherent connection between Indigenous knowledge and associated worldviews, with original language sources, serves as a primary means for supporting the survival of Indigenous knowledge systems (McKinley 2005). In the NSFCs, Native languages were necessary for understanding the diversity of traditional relationships present within local ecological communities, and Native language use emerged throughout the project activities as field sites actively used language instruction to enhance, support, and at times rewrite the science content. Each site developed their own culturally relevant taxa data inventory to use in the field. Students used Native languages to identify and inventory culturally significant plant and animal species, thereby reconnecting participants with cultural practices through both ancient stories and contemporary field practices.

By shifting towards Indigenous education, and away from educational programs that have historically been associated with an interruption or suppression of Native language transmission, this practice demonstrates how culture can continue to be understood through language (Nicholas 2010). Informal education programs for youth and adults serve an important purpose for revitalizing and sustaining Native languages. In order to work effectively, all aspects of Native language education need to be "supportive, rather than disruptive, of intergenerational and everyday uses of indigenous languages in community life" (Arenas, Reyes and Wyman 2007, p. 42). The Wind River site, for example, made extensive use of the Shoshone language in its programs. The table of elements was translated into Shoshone as well as relevant concepts from Shoshone physics. The Shoshone concept of *moogwa*—which relates to senses of motion, disorientation, balance,

and acceleration—was used to explore and enlighten parallel concepts from physics and biology. For lessons such as these, the NSFCs were fortunate in their ability to employ Elders (the term "elder" is capitalized throughout this study as a title of honor for those individuals who are recognized as knowledge holders and role models within their Indigenous community) fluent in the Blackfeet, Lakota, Shoshone, and Arapaho languages. As Lisa Lone Fight, one of the authors of this paper and former director of the Wind River Native Science Field Center reasons, "our languages developed from and are representative of the natural world. They are rich in the ability to explore processes and states and are essential to an understanding of the relational science of Indigenous people. They speak to the very basis of what it means to be an Indigenous scientist."

Indigenous evaluation

Along with a focus on Native language, the NSFCs used evaluation methodologies and processes that are informed by Indigenous perspectives, particularly at the formative evaluation level. This approach mirrors community-based participatory research, where all team members are active and have equal input into evaluation design and activities. The most important part of using an Indigenous evaluation process is to create relationships, where boundaries can be crossed and the voice of the community can be shared in a meaningful and respectful way. This type of process recognizes the diversity of experiences and traditions that exist in Indigenous communities. Recently, there has been a thrust to change the way evaluation is conducted with programs serving Native communities (LaFrance and Nichols 2009). In the past, research and evaluation practices created fear and distrust, resulting in historical trauma of past research practices being used within Native communities. Using an Indigenous evaluation process provides a better understanding of evaluation among Native community members and provides for more local control and input. Indigenous communities seeking to remain empowered throughout the research process can benefit from an approach that respects their unique cultural values, epistemologies, and allows for increased levels of engagement. Indigenous evaluation processes also serve broader impacts beyond Native American communities as a growing number of participatory and community-based projects seek a framework for engaging participants in all aspects of research, including evaluation.

For our tribal-based ISE programs, we emphasized an evaluation process that is qualitative in nature, while including quantitative data collection aspects for specified activities. We used quantitative methods specifically for documenting change over time in student experiences. Mixed methods are especially useful in NSFC evaluation for: self-assessment; community-created surveys; non-intrusive observations; small group and, when appropriate, individual interviews; case studies; evidence of participatory and active engagement; and analysis of science stories from Indigenous perspectives. Along with being user-friendly, several additional evaluative and analytical tools that are relevant to Native worldviews include: photovoice, thematic wall activities, and field journals. Photovoice employs participatory photography, in which community members document and then discuss happenings in their community (Wang and Burris 1997). Using the combination of these types of approaches and strategies has been found to be both relevant and appropriate to use within community-based participatory research educational programs that work with Native American communities and focus on shared evaluation process. This process is also encouraged by the American Evaluation Association (2011). The NSFCs employed several

evaluation techniques that are commonly cited in the research literature on Indigenous evaluation practices. The uniqueness of these evaluation resources is that they have grown organically from within Indigenous communities themselves, bringing Native voices to the playing field of evaluation. For Native people, this is an important step towards creating and facilitating outcomes that reflect Native ways of knowing. As Dr. Shelly Valdez, one of our authors and the NSFCs' principal evaluator explains, "evaluation is all about telling stories. Storytelling has always been an important part of Indigenous peoples' cultures. In the case of evaluation, it is how we craft the story using project data that reflects the impacts and outcomes of those involved in the process."

Profiles of the Native Science Field Centers

A closer look at the Native Science Field Centers reveals diverse characteristics that formed the foundation of their community-specific frameworks. Each community varied in geography, history, and tribes present. Through providing demographic profiles of the individual NSFC sites we continue to share a piece of the process of building and implementing environmental science programs that integrate Native ways of knowing and Western science. The NSFC model sought to incorporate Native ways of knowing to create a deeper sense of connection to place from a tribal perspective. This led to a decision to work collaboratively with communities toward implementing a participatory planning process approach.

During the crucial planning process the Blackfeet NSFC site created a strong community-based project foundation that was continued in succeeding NSFC sites. Bordering Canada to the north and Glacier National Park to the west, the Blackfeet Reservation occupies approximately 1.5 million acres of land in northwest Montana. Traditional territories originally extended well into the Rocky Mountains to the west of the existing reservation and far into Canada.

The Blackfeet NSFC was housed at Blackfeet Community College (BCC) located in Browning, Montana. The K-12 students were transported from the local area schools to participate in the field science activities held on campus. In addition to providing educational resources and cultural presentations for local teachers, the Blackfeet NSFC collaborated with BCC departments to hold large-scale community events. The Blackfeet NSFC gained community support each year while in operation and continued to increase youth access to science and math resources, in addition to traditional ecological knowledge learning opportunities. Helen Augare, lead author for this paper and program director of the Blackfeet NSFC expresses that, "providing our youth with a balance between learning Western science and valuing our cultural knowledge will give them the courage to step out of the box, experience new things, and think for themselves so that they can be successful, confident, and strong leaders when they make decisions for our community in the future."

The values and lessons that emerged from the Blackfeet NSFC loaned themselves to the development of the Lakota NSFC the following spring. The Lakota NSFC was housed at the Lakota Center for Science and Technology at Piya Wiconi campus of Oglala Lakota College (OLC) on the Pine Ridge Indian Reservation in Kyle, South Dakota. The Pine Ridge Indian Reservation, located in the southwest corner of South Dakota, covers over 2.8 million acres. Since the center was located within the Lakota Center for Science and Technology at OLC, there was ample opportunity to balance the curriculum with both Western scientific knowledge and Native ways of knowing. As Helene Quiver-Gaddie, former director of the Lakota NSFC and author for this study argues, "our kids have to be informed of their rights and know the land."

One year after the Lakota NSFC was established the Wind River NSFC began its program. Both the Eastern Shoshone and Northern Arapahoe tribes share the Wind River Reservation in the mountainous region of southwestern Wyoming. The Wind River NSFC was housed within the Fremont County School District at Fort Washakie Charter High School in Fort Washakie, Wyoming. The Wind River NSFC served and impacted youth and community members living within a 2.2 million acre area. Building partnerships was an important aspect of working towards sustaining the Wind River NSFC. In regards to her work at the Wind River NSFC Lisa Lone Fight, former NSFC director and an author for this study, states that, "we want to empower our reservation as a whole through education and training, and that acknowledging that we are different and distinct helps us learn to work together to support our youth."

Further details about each NSFC are presented in Table 1. The information in this table highlights demographics of tribal communities.

Additional information about each NSFC regarding who was served and an annual average of how many youth and adults were served is presented in Table 2. Averages are based on records from 2008 to 2011 for Blackfeet and Lakota NSFCs and from 2009 to 2011 for Wind River NSFC.

As shown above, NSFCs were independent of one another; however they did have several characteristics in common. The NSFCs each utilized a similar organizational strategy in terms of their funding, reciprocal capacity building, and program approach.

The NSFCs were funded by grants from the National Science Foundation and the Bush Foundation as well as receiving some support from educational institutions where they were housed. Hopa Mountain served as the program coordinator for the two grants and administered funds to each NSFC through a sub award. Hopa Mountain provided technical, training, travel, and meeting support to NSFCs through the development of ISE programs

Table 1 Tribal community demographics

Name of NSFC	Name of reservation	Location	Tribe(s) served	Reservation population	Time of inception
Blackfeet NSFC	Blackfeet Indian Reservation	Northwest Montana	Blackfeet	10,400	November 2006
Lakota NSFC	Pine Ridge Indian Reservation	Southwestern South Dakota	Oglala Lakota	38,000	Spring 2007
Wind River NSFC	Wind River Indian Reservation	West central Wyoming	Eastern Shoshone and Northern Arapaho	26,490	May 2008

Table 2 Profile data for each NSFC

Name of NSFC	Target audience	Average annual number of youth	Average annual number of adults
Blackfeet NSFC	elementary, middle, and high school students and adults	1080	983
Lakota NSFC	middle school and high school students and adults	974	245
Wind River NSFC	elementary, middle, and high school students and adults	147	380

as well. NSFC program directors attended NSFC Leadership Team Meetings coordinated and facilitated by Hopa Mountain staff. The meetings targeted capacity building, strategic planning, evaluation training, and sustainability efforts. Leadership training and education sessions provided opportunities for NSFCs to learn from one another and to develop best practices. Hopa Mountain also subcontracted a principal evaluator who coordinated evaluation for all three NSFCs.

To effectively oversee the development of each community's NSFC a Community Advisory Board consisting of local community members who were knowledgeable about local culture and education was established at the beginning of each program. The Community Advisory Boards were an integral part of each NSFC program and aided each NSFC's program director and staff in curriculum development and implementation.

Although most of the NSFC participants were Native American, the NSFCs were cross-cultural programs that emphasized both Native ways of knowing and Western scientific ways of knowing in their program approach. While community Elders and cultural leaders provided Native ways of knowing for participants, researchers and experts in STEM fields focused on a Western scientific perspective during the field experiences. The NSFCs ran separate seasonal institutes throughout the year and offered their programs to all students in the community.

An annual NSFC Summer Gathering event brought together Native and non-Native students, adults, educators, community members, and interns from all three NSFCs to share knowledge and experiences. Hopa Mountain staff helped plan, coordinate, and participate in the Summer Gathering event. During these events the NSFCs worked collaboratively to engage students, teachers, and Elders from all three communities to share their experiences and learn from one another.

Although several similarities have been duly noted, each NSFC was distinct due to the educational institutions in which they were housed. Programs offered were uniquely relevant to their respective communities, tribal cultures, tribal traditions, tribal languages, and Native ways of knowing. NSFCs may not have shared the same environmental issues or needs to address those issues. The NSFCs focused on a wide array of educational practices, including a range of perspectives and approaches to ISE. Each NSFC was administered according to the specific needs, staffing, Community Advisory Board, and limitations present in their respective communities (e.g., access to varying community resources). Furthermore, every NSFC underwent a separate process (i.e., formative) evaluation completed by an evaluator who was selected from a pool of evaluators and worked with the principal evaluator.

The Native Science Field Center model

Collectively, the NSFCs had four goals: (1) to develop the existing field centers as a model to replicate with future programs in neighboring tribal communities; (2) to expand STEM career-ladder learning opportunities for youth and adults by strengthening math and science teaching and increasing participation in each community; (3) to develop appropriate Indigenous evaluation tools and methodologies for use in program evaluation; and (4) to document best educational and evaluation practices that could be disseminated to inform community members, other tribes, and the ISE community. At the very basis, and to effectively meet these goals, the Native Science Field Center model sought a ground up approach informed by local Indigenous perspectives. In order to provide a model that could be replicated in other tribal communities, the NSFCs were required to develop a place-based, culturally responsive framework. This framework is grounded in the establishment of Community Advisory Boards, which lead to the development of seasonal, culturally

relevant, field-based program activities for youth and adults. This model framework was additionally supported through ongoing partnerships, outreach and trainings.

Community Advisory Boards

Community Advisory Boards (CAB) were established by project staff to foster and maintain the participatory process. CAB group numbers averaged from 7 to 11 members. During their regular monthly meetings, CAB members discussed the importance of field education and teaching youth the culture and language. CAB members consisted of parents, Elders, teachers, educators, and fluent speakers. Through sharing culturally relevant information with program staff (e.g., traditional sites or seasonal activities that were important to the community's cultural knowledge and history) CAB members helped to establish essential educational requirements that guided the NSFC curriculum development for each tribal community. In turn, each site worked to create innovative local action plans to establish necessary goals and meet the unique cultural education needs of individual tribal communities (e.g., defining learning motivations and interests for students and adults, increasing student retention, increasing language acquisition). Each year the NSFCs worked collaboratively with local CABs, site cross collaborations, and with Hopa Mountain staff to develop informal community-based science activities for youth and adults. The different layers of activities implemented at the local level included youth programs (seasonal institutes and other community engagement events), professional development training for educators, and community engagement activities.

Seasonal, culturally relevant, field-based program activities

It was out of this participatory planning process that Community Advisory Board members recognized the importance of providing meaningful, culturally relevant learning opportunities for participants within the cycle of the seasons. This process demonstrates a central principal of community-based, participatory research by reflecting local ideas and values (Kindon, Pain and Kesby 2007). Community Advisory Board members noted that by allowing for seasonal programming, participants experienced the natural elements and weather conditions that would realistically be endured in the field by both their ancestors and modern field scientists. Afterschool and summer programming fully engaged participants throughout the year.

STEM opportunities were created throughout the NSFCS by engaging youth and adults in field experiences that built from basic survey skills to mapping, monitoring, and decision-making. They were designed to reconnect youth and adults with their environment through cultural and scientific field programs. Science protocols, inquiry-based education, and skill development with an engaging set of field experiences were integrated to form the foundation of each NSFC.

These NSFCs were founded on the conviction that field-based programs are essential and beneficial for science education (Zwick and Miller 1996). Field centers support active engagement in exploring nature, increase and naturally integrate knowledge and interdisciplinary relationships that are present in the environment, and boost interactive discussion in contrast to individual work in the classroom (Zoldosova and Prokop 2006). Additionally, lessons taught in the field are often the easiest for incorporating both Native ways of knowing and Western scientific ways of knowing, since the locations contain both scientific and Indigenous cultural information (Riggs 2005). The following descriptions detail an annual pattern of NSFC seasonal program activities by site location. Activities are organized to focus on connection to place, using seasons as a way of defining the year. This

structure also served as a way of preserving cultural norms and was fundamental for conducting community-based work. Seasonal educational science institutes were offered to students and adults. The seasonal institutes ran for approximately 6 weeks with the curriculum organized and presented around traditional cultural activities appropriate for that particular time of year.

Blackfeet NSFC

Beginning in 2009, the Fall Institute focused on holistic cycles of life such as communal, parasitic, and mutual relationships in nature. For example, students learned about the relationship between white bark pine and bears. Students were taught to reflect on how learning to observe animal behaviors helped them to better understand their own traditional practices of physical and social development. For example, the Blackfeet historically observed patterns of elk movement and migration, and this helped them to decide the best routes for their own travel. Similarly, the traditional practice of observing muskrats building homes on ice in the winter informed the Blackfeet that it was going to be a cold winter. Paying attention to such details helped the NSFC students realize that they can have an intimate relationship with their environment and learn from the plants and animals around them. In another lesson, they were able to compare the caching habits of the Clark's nutcracker to the Blackfeet tradition of carrying, storing, and transporting articles with parfleche, a traditionally prepared material made from rawhide. The Fall Institute also included traditional Blackfeet animal stories and how to build a cradleboard device for securing babies that also assists in the child's physical development. This activity showed the students the process of turning animal skin into rawhide, explained the properties of cradleboard wood, and detailed what type of wood is preferred to build the cradleboards.

The following 2010 Winter Institute, held for 6 weeks in February and March, taught students the physics, chemistry, and history of drum making, bows and arrows, snowshoeing, and astronomy in the context of Blackfeet tradition. Students were involved in making tools used within traditional homes such as willow backrests, as well as tools used for winter hunts and survival in the snow. Other activities included exploring traditional hunting and trapping techniques and a student produced dramatic performance in the Blackfeet language focusing on climate change. In addition, students learned about winter weather patterns, glacier formations, and the significance of glacier fed streams in their tribal community. The Blackfeet NSFC also held a Winter Institute specifically for middle school students focusing on the Bear River Massacre that occurred in 1870. It included intensive research on survivor stories, archived documents, genealogy charts, and transferred knowledge of specific landmarks and land-based environments important to the Blackfeet people. Students learned how to audio record personal interviews and produced audio/visual presentations of their research.

Also in 2010, the Spring Institute focused on soil conservation and botany. Topics included native plant knowledge, soils, water, Global Positioning System (GPS) mapping, climate change, and the flood of 1964. Students dissected fruits and vegetables and identified seeds, talked about seed germination, measured water and soils used for planting, measured seed depth for planting yarrow, and prepared raised beds for native plants with a 1.5 acre plot owned by BCC. This garden allowed teachers and students to work collaboratively to grow traditional native plants. Other spring activities included measuring precipitation and looking at precipitation maps, building smudge boxes, and learning the importance of the soil where smudge plants—such as sage—are found and when to find them.

Summer Institutes were held separately for grades 4–6 and grades 7–8. Summer activities included field experiences in Glacier National Park, native homeland to the Blackfeet.

Lakota NSFC

During the school year, the NSFC found a way to fill a gap in the education of Pine Ridge students. Little Wound High School in Kyle, South Dakota and Bennett County High School in Martin, South Dakota cut their academic school week to only 4 days. The NSFC stepped into provide academic activities for juniors and seniors at these schools by holding all-day science Fridays and occasional Saturday field activities. High school science, math, and Lakota language instructors supplemented the activities, which ran from October through December. Field experiences included visits to educational centers such as the South Dakota Discovery Center and Aquarium, South Dakota School of Mines and Technology, Chadron State College in Nebraska, and Black Hills State University. These visits introduced the students to the educational opportunities that awaited them in areas that were not far from their homes.

The Summer Institute focused on local flora, fauna, and invasive species and worked to raise participant awareness of environmental issues relative to the Pine Ridge Reservation and surrounding areas. In the summer of 2009, the Lakota NSFC took their students into the field every day to explore the geology, biology, and ecology of their surroundings. Summer excursions included LaCreek Wildlife Refuge, Mammoth Site, Buffalo Pasture, Slim Buttes, and Badlands Overlook. During the Summer Institute, local spiritual and cultural leaders, as well as geological engineering and water experts, accompanied the group on field experiences to the Badlands and Wind Cave National Park. Community Elders shared their knowledge of native plants and animals as well as the cultural significance and history of local places with NSFC students. One Elder spent over a week with the students in the summer of 2009. During that time, he shared his knowledge of native plants and the contents of a soil, called *Wase* in Lakota Native language, which was used as a paint-like covering for ceremonies. He also took the students to sacred Lakota locations like Humbleca Paha, a vision quest site.

Wind River NSFC

Fall topics included food-gathering (harvesting), hunting, classification of living things, and identification of edible and medicinal plants. Learning respect for and conservation of the natural world and natural resources was an important goal of the program.

The Winter Institute covered animal homes and winter survival, how to identify animals by their tracks and scat, and sky science (weather and astronomy). During the Winter Institute, Native American stories of the skies and stars were also shared. Winter field trips to the Wyoming Sheep Refuge and the Wyoming Elk Refuge engaged youth in learning about wildlife and range management, animal habitat, science, migration patterns, traditional uses, and hunting methods of elk and sheep from the Arapaho and Shoshone tribes.

Spring topics included new life, hydrology (water cycle), soils (rock cycle), birds, and life cycles of plants. Summer topics included ecology; food chains; observations; collections; surveys and analysis of water, trees, and forests; exploration of local lands and resources, geology, and climate change. During the summer session students had extended time and learning opportunities to explore and study their "place" in greater detail by conducting practical analyses of their living and nonliving environments. During the summer of 2010, Wind River NSFC students also joined youth and adults from other NSFC sites at the Tetons Science School.

This NSFC additionally offered Science Saturdays to Wind River students. Saturday activities introduced several additional topics such as geography, finding locations with

GPS technology, wildlife habitats, animal (i.e., elk, sheep, antelope, and bear) ranges, hibernation and migration, seasonal change, recycling and reuse. During Science Saturdays, Native language and traditional knowledge were included as a cultural component in all learning activities through active participation by Elders who shared traditional knowledge and stories.

Partnerships, outreach, and training

As observed in the NSFC profiles, program activities evolved in a variety of scientific subfields and traditional knowledge areas based upon the resources available in each individual community. One of the greatest strengths of the NSFCs to support these unique programs was in the extensive community partnerships, outreach events, and training opportunities within each site.

Blackfeet NSFC

The NSFC hosted a number of programs and activities for the community. "Days of the Blackfeet" was organized as an annual outreach activity, bringing together the entire community for cultural workshops, keynote speakers, and a parade. They also implemented a culture and language immersion program in the spring of 2010. The program focused on Blackfeet Language conversation and cultural training and offered language immersion campouts for families on the weekend. The NSFC also led 30–40 environmental science seminars per year.

The NSFC staff attended workshops and meetings as much as possible. NSFC directors attended conferences such as the 2010 American Association for the Advancement of Science meeting on climate change. Here they learned how different groups are addressing and educating youth about topics such as climate change and began to think about how these ideas might translate to rural and Indigenous communities. Locally, the NSFC staff worked to have a presence at meetings or activities that impacted land and resources. For example, an active involvement at community meetings on rewriting the Blackfeet Tribal Constitution encouraged the conversation to focus beyond only social impacts to emphasize environmental awareness, managing waterways, and natural resources. By continuing to be involved in these activities, the NSFC staff was able to remain aware of and involved in STEM related issues in the community for the purpose of integrating what they learned back into the NSFC programs.

For evaluation, the NSFC invited parents and community members to participate in a "winter count" with student participants. A winter count is a traditional way to record the history of past events using pictures. Drawing a winter count helped to record what students recalled and what they enjoyed the most from each week. Parents and the community discussed what the children liked and suggested topics and activities they would like them to learn in the future.

Lakota NSFC

The Oglala Lakota Center for Science and Technology both housed and partnered with the Lakota NSFC. This relationship allowed the NSFC to have ready access to scientists engaged in local research and gave both the community Elders and Western scientists the opportunity to share their experiences during NSFC events. OLC science students had the opportunity to intern with the program, working alongside the NSFC director to implement

project activities and goals. This exposed college students to the NSFC teaching methods, offering them the opportunity to interact with younger students and encouraging them to focus on STEM related academic interests. This also provided a window for youth to look at higher educational pathways, particularly those housed at OLC.

One of the main outreach activities provided by the NSFC was the Community Science Nights that were held once a month at a tribal or off-reservation school in partnership with OLC Lakota Center for Science and Technology. These consisted of science exhibits such as star labs and robotics demonstrations. These events were scheduled in the evenings so that students, their families, and community members could attend and typically had 100 or more participants. Another form of outreach was providing opportunities to attend other local cultural and science programs by co-sponsoring them, such as the Cloud Horse Institute Winter Camp near Kyle, South Dakota. The NSFC also offered environmental seminars and trainings throughout the year to increase environmental awareness in the community. One environmental seminar consisted of teachers from the OLC Science Department discussing water ecology and macro-invertebrates. The NSFC also partnered with the OLC Math and Science Department to sponsor a booth displaying a star lab, a paleontology exhibit, and chemistry exhibits at events such as the Lakota Nation Invitational in Rapid City, South Dakota.

Wind River NSFC

Partnerships motivated students to think about STEM careers in the future and include national research and educational organizations. Among the organizational programs the NSFC collaborated with to provide educational opportunities were the National Weather Service, the U.S. Fish and Wildlife Service, Wind River Diabetes Program, Fremont County Farmer's Market Association, Central Wyoming College, Department of Environmental Quality, U.S. Forest Service, and the Teton Science School. Local collaborations with programs such as the Diabetes Program helped the NSFC to develop lessons such as food sciences curriculum.

Local partnerships were cultivated with the Eastern Shoshone and Northern Arapaho joint tribal councils and the school administrations. The NSFC included cultural traditions from both tribes in the programs. Acknowledging that the tribes had separate tribal councils, languages, and cultures was vital towards learning how to work together. The NSFC established a good working relationship with both tribes by agreeing on and signing tribal resolutions with both of the tribal councils.

The NSFC was part of a larger Wind River Rural Systemic Initiative (WRRSI). The WRRSI included five schools on the reservation and worked to enhance math and science instruction for young Native American men and women in an effort to promote access to high quality educational opportunities by connecting tribal colleges with elementary and secondary schools. The WRRSI program promoted more hands on math, research-based math and science, curriculum development for technology use in math and science, and free Advanced Placement math and science courses for any student on the reservation.

Assessing impacts using mixed methods and participatory evaluation

Case studies at the NSFC sites provide a rich, in-depth understanding of potential motivation, interest and academic benefits gained by Native American students who regularly participate in informal science educational programs that incorporate traditional Native

American values, perspectives, and language into field experiences and activities. In order to assess the impacts of these programs, summative evaluation questions were addressed including:

- To what extent and in what ways can the processes, knowledge, and practice of culturally relevant environmental science programs be strengthened and deepened locally?
- To what extent and in what ways can the processes, knowledge, and practice of culturally relevant environmental science programs be transferred nationally to other sites/contexts?
- To what extent did participants (youth, ages 8–18) in the newly established field programs and existing sites gain competence in environmental science and cultural knowledge through their participation in NSFC activities?

Summative evaluation measures were informed by the National Research Council's recently developed learning strands addressed in *Learning Science in Informal Environments*, specifically Strand 4 (reflecting on science as a process or way of knowing) and Strand 6 (developing a science-related identity), as these two strands are most relevant and aligned with the NSFC model (National Research Council 2009). Impact outcomes for participants were measured using the National Science Foundation's (NSF) impact indicators for ISE programming developed for the NSFCs. NSF indicators included the following:

- Native Science Field Center youth participants will increase their knowledge of science, traditional knowledge and Native language as it relates to environmental science.
- Native Science Field Center youth participants will increase their interest in environmental science, traditional knowledge, and Native language.
- Middle school and high school aged youth will regularly participate in Native Science Field Center programs.
- Adults, families, and community members will increase their interest in environmental science, traditional knowledge, and Native language as a result of participating in Native Science Field Center programs.

Both qualitative and quantitative methods were employed each year to further address these areas in the form of in-depth individual and focus group interviews, participatory evaluation activities, and surveys. Each year, the NSFC site administered a pre-survey and followed up with post retrospective surveys with program participants. The pre-survey was only administered to new, incoming Native youth on a yearly basis. At each NSFC site, in-depth group interviews for seasonal activities were conducted annually with program participants. Additionally, two seasonal project activities were also observed yearly with feedback provided to the NSFC local staff.

Interviews were based on questions collaboratively developed by the leadership team and lead evaluator. Most youth participated in focus group interviews in which a series of questions ($\sim$29) guided the group conversations. Focus group sessions were audio taped and then transcribed and coded for themes targeting the NSF ISE indicators and impact outcomes. Additional focus groups for parents as well as in-depth interviews of a representative sample of adult participants (parents, presenters, and CAB members) were also facilitated for each seasonal institute at each site. During the Annual Summer Gathering, Elders were interviewed in informal conversation as opposed to formal interviews. Where applicable, tapes of these interviews were also transcribed and coded for themes based on NSF ISE indicators.

To further assess outcomes for participants, the thematic wall of impacts served as one of the primary participatory evaluation activities at the NSFCs. This activity asks participants to rank target impact areas which are aligned with the goals of the program and the NSF impact indicators for ISE programming. This activity includes two parts: (1) ranking the impacts, which takes approximately 20 min and (2) discussion of ranking, taking approximately 30 min. The evaluator walks participants through the process so participants obtain a clear idea of the activity. Participants are provided with round stickers (Avery labels) and are asked to number them 1–8 (i.e., 1 = most impacted area, 2 = second most impacted area, and so forth). As an example, participants were asked to rank areas such as "I have increased my understanding of science," "I have increased my learning of traditional language as a result of being involved in NSFC," and "My parents are more interested in learning about our community environment because of my involvement in the NSFC." Participants are also provided with an open space area for 'other comments' to allow them to share other impacted areas that may not be on the wall area. The participants walk around the room placing their ranking stickers.

After this portion of the activity is completed participants engaged in a conversation around why the group ranked items in certain ways. The evaluator prompted the conversation by asking participants what they noticed (e.g., which impact areas seem stronger or less strong) and then prompt them to discuss why they made the choices they did using the following types of questions: "Why did you rank these impacts higher than others?"; "What about the (seasonal institute) do you think led to higher impact in these areas?"; and "What could have been done to increase impact in these lower areas?".

The Wind River NSFC favored Photovoice participatory photography activities for evaluation. Photovoice used photos, video, and audio interviews to capture the knowledge and interest youth had in their community. This method proved unique in its ability to allow adults to see their community and vision for the future through the eyes of the youth.

In 2011–2012 additional data on seasoned NSFC participants were collected through a supplemental study. This study included pre and post survey data to assess target areas of student impacts. Surveys consisted of 38 questions, focusing on four target areas: interest, motivation, benefits (academic and traditional), and leadership skills. The areas included Likert scale questions and open-ended questions. The data for all surveys were transferred to Zoomerang, an online survey tool for analysis and reporting. Surveys were administered several ways: onsite during the NSFC Summer Gathering, on-line, through conference calls or on-site at their perspective communities. There were a total of 69 participants (29 Blackfeet NSFC, 13 Lakota NSFC, and 27 Wind River NSFC) who completed the supplemental case study surveys (42 % male and 58 % female).

This study also included qualitative data from two levels of in-depth telephone interviews with eight seasoned NSFC participants (50 % male and 50 % female). Originally, interviews were to represent three students from each site; however one student was unable to be reached. The first questionnaire consisted of 22 questions and each interview lasted between 20 and 30 min per participant. The second level of questions consisted of 25 questions that were follow up questions to obtain a deeper understanding to the responses from the first level of interviews. Level two interviews lasted an estimated 30 min per participant. Both levels of questions were collaboratively developed by the leadership team and the lead evaluator.

Narrative themes

Narratives from NSFC interviews, focus groups and activities were gleaned for key words and concepts that coincided with any or all of the four broad goals of the NSFC program (identified in the Native Science Field Center model section of this paper). Subsequently, five patterns in the narrative data emerged. Under each theme, a description and relevant quotes illustrate the thematic content. In response to a discussion with our collaborators, we have avoided the use of pseudonyms for participant quotes in this article to ensure cultural sensitivity and to sustain the intention that the students' stories carried. To better explain, during the course of this study students were informed that their words were "alive" and that even on paper these quotes represented their breath that was taken to speak and to carry on the oral expression that they provided. These thematic findings represent core elements that when woven together create a unique informal science learning experience for Native American students.

Traditional knowledge and field science experiences

Learning to identify native plants and animals was an ongoing activity taught across all NSFCs. By using field guides to identify abundant traditional native plants and animals in the community, students were able to take biodiversity ecological surveys to develop a biodiversity profile of a site. These profiles could be monitored from season to season, teaching observations like how plant conditions relate to weather and the blooming season of the respective plants. Students were taught to observe the diversity of plants and animals in an area. Specifically, they gained skills on how to scrutinize nearby roads; identify whether a site was grazed, mowed, or irrigated; determine if there was a presence of pesticides; know how much sunlight the site received; and identify the latitude/longitude of the site.

Community Elders shared their knowledge of native plants and animals, cultural significances, and history of local places with NSFC students. For example, finding dried out blue bunch wheat grass in May can indicate that there is a drought. Plants like sage or rough fescue may only be used for smudges or ceremony at certain times of the year. Students learned about the importance of asking permission (e.g., earning the cultural rite of passage) to harvest certain plants, and how to take parts of a plant without overharvesting to ensure that the plants continue to thrive within the environment. Offering respect by praying for plants before they were picked and learning community knowledge and historical significance of a field site were also important lessons offered by this field activity.

In the findings from the 2011 to 2012 case study, 78 % of the case study participants indicated that it was important to learn about animal behavior and seasonal patterns. Additionally, the percentage of participants indicating that they are strong at making observations about the environment increased from 68 to 83 % after participating in the NSFC. Participants indicated that the increase in interest was linked to their participation in the NSFC program. Outcome data also showed an increase from 88 to 95 % of participants indicating an interest in learning about traditional knowledge after participating in the NSFC. During the 2011–2012 case study, one high school age youth participant indicated that participation in the NSFC program had given them the motivation to perform additional science research for their environmental class, saying "I decided to talk to [my teacher], to see if I could do some research on Native studies in the science areas, as medicinal plants and healing, how we used them, and where they were found and to use it to write a paper and to earn credits. Also, to help [my teacher] understand how we learn as Native people from

our Elders. [He] was willing, really willing; he was one of the few people I met who learned to embrace our culture as a whole instead of something just to learn about. He was happy to do this, and it got me through one or two of my science classes."

Cross-cultural sharing

Summer Gatherings provided a forum for the NSFC participants from each community to spend time together. The inter-community dialogue during these gatherings emphasized working on common goals and how similar issues are being addressed. As a result of these interactions, support networks emerged holding potential to provide assistance for students as they fulfill their educational goals and come into roles of leadership in their own communities.

At the 2009 NSFC Summer Gathering, students learned some Lakota, Blackfeet, and Shoshone words; played cultural games like Double Ball; and shared cultural stories and foods with the group. With the help of a Lakota Elder, some of the Lakota NSFC students cooked a traditional Lakota dinner of *tinpsila* (wild turnip, pronounced teem-psi-lah) and *papa* (dried meat, pronounced pah–pah) soup, chokecherry *wojapi* (pudding, pronounced woh-zjah-pee), fry bread, and buffalo ribs. They shared the origin of the *tinpsila* story and an Elder led the group in a Lakota blessing. Additional Summer Gathering activities included a plant identification walk with Elders from the Blackfeet community who pointed out native plants that have medicinal qualities such as antibiotics and fluoride. Students learned the importance of respecting these plants and the sun for the medicines that they provide by remembering and saying their Native names in Shoshone, led by an Elder from Wind River.

In 2010 the NSFC Summer Gathering was held near Jackson Hole, Wyoming at the Teton Science School. This gave participants the opportunity to visit what were historically traditional Shoshone lands, sacred sites, and geological wonders such as Yellowstone National Park. Summer Gatherings were cross-cultural in content as well as in the backgrounds of the participants involved. One high-school age youth who participated in the 2011–2012 in-depth case study follow-up interviews expressed "I loved learning from the other tribes and their cultures… I like the idea of having and sharing ideas of culture and it's that people make the difference so noticeable and we all have so much in common."

Community support

Many Community Advisory Board members were current or retired educators and/or cultural advisors. Examples of their involvement in program activities included their consultation with a program director regarding which cultural sites students would visit or what types of cultural topics they should focus on. Community Advisory Board members were welcomed to attend every NSFC leadership/training workshop, meeting, and event. They were also invited and often participated in field activities with students. During these activities Community Advisory Board members shared their knowledge with students and, whenever possible, the appropriate usage of the respective Native language. Providing a way for adults to participate in children's education in this format often inspires them to further their own education (James 2001).

Elders from the Blackfeet NSFC that participated in interviews recorded in an NSFC Year-Five Evaluation Report indicated that they had changed through their involvement in the program (Valdez 2011). Many cited an increased self-worth because of being asked to share their knowledge, public speaking skills, and role modeling and noticed a feeling of respect among the community for their skills and traditional knowledge they have to offer.

At the Lakota NSFC, one presenter from the community, whose interview was also summarized in the evaluation report, detailed how their involvement had provided leadership opportunities and partnerships for them. This presenter came into the program as an intern and served as a mentor and chaperone. After completing a degree, this presenter served as a science partner and collaborator.

Findings in the 2011–2012 case study emphasized further impacts the NSFC program has had on the participants with an increase from 78 to 90 % of the participants indicating an interest in becoming more involved in their respective communities after participating in the NSFC program. Outcome data also indicated a higher interest in accessing traditional community activities and students recognized that learning from the Elders extended new learning opportunities. During the 2011–2012 case study in-depth interview, when asked if they thought the NSFC had helped them to understand science more, one high school age youth responded that "In general it helps us understand academic pursuit of science and it helps to understand our culture and histories…We both learn from Elders and teachers."

Parental involvement

Parents of NSFC seasoned participants were invited to participate in focus groups and interviews. Summaries from these interviews were also recorded in the year-five evaluation report (Valdez 2011). In these reports parents expressed seeing positive changes in their children in terms of retention, behavior/attitude, influences on academics and career, influences on culture, and language acquisition. Parents indicated that their children were more willing to engage in outdoor activities and transfer the knowledge to their parents as a result of being involved in the program. A majority of parents from the Wind River NSFC focus group indicated that their children became more respectful and willing to learn, and that they encouraged other family members to learn more about culture and language. Parents from this group also noticed their children using more science related language and terms within the home environment after participating in the NSFC program. One parent from the Blackfeet NSFC Spring 2011 parent interviews indicated that discussions were taking place at home about possible career pathways in science areas, and attributed this thinking to involvement in the field center program (Valdez 2011). Both this parent and one more who participated in the Blackfeet NSFC interviews that year expressed that their children had strengthened their traditional language skills and that they were eager to speak in the home environment. During a December 2010 Wind River NSFC parent focus group interview, parents shared that a few youth from the NSFC had also inspired their families to get involved in community events and ceremony, re-engaging them with the traditional side of the community (Valdez 2011).

Advancing informal education and learning

NSFC educators worked to impart traditional values into their lessons. For example, on a berry-picking excursion, the director of the Blackfeet NSFC described how to make serviceberry soup and suggested that the students bring the berries they pick to their teachers instead of an apple on the first day of school. Though subtle, this is one way teachers can encourage students to affirm their culture in daily activities.

Another example under this theme was illustrated in the activity where a tribal Elder showed students a type of paint that is traditionally used for ceremonial face painting. The Elder provided the Native name for the paint, shared a story about the paint, and explained

that certain rites may be required in order to gather sacred things such as paint. Using this same paint, students were taught Western scientific properties of soil types and why certain elements, like iron, have a particular color. Students also discussed the locations of these soils within their communities. As one Community Advisory Board member from the Lakota NSFC shared, "My grandfather always said, 'We have five senses. If you use all five of your senses to learn something, you learn it well.' That is exactly what the NSFC is doing for our kids."

Through their involvement in the NSFC program, youth were motivated to continue their learning beyond the field center. A majority of youth have continued their learning in science, Native culture, and language. A majority have continued to work with Elders to deepen their understanding of language and culture on their own. The main area that motivated these youth to continue being engaged in the field center program was the application of learning experiences to life's daily environments. By being involved with the NSFCs, a better understanding of traditional concepts parallel to modern concepts can be identified. A more profound understanding of both concepts and how they are similar or different engaged the youth to further their knowledge in both the educational and traditional aspects. With most youth, the desire to help their community or give back to their community through learning new skills from their culture and academia was key. They were able to see and share examples of how the knowledge and skills gained through their involvement in the field centers was applicable to their culture, their community, and their continued learning. During the 2011–2012 in-depth case study interviews, when asked if their NSFC experience motivated their life or performance in school, one high-school age participant stated that, "It definitely was a motivating factor because it helped tie everything in more holistically for me. So one of the problems I had with science it seemed very impractical and didn't connect to anything that had connection to me, or the world around me. One thing the NSFC helped show me is there are connections; you may just have to look for them. It helped me see it does connect to me and apply to the world around me, in ways that aren't just written on paper, not just calculations. As long as you can include those it helps you and is an important tool as well…For me it helped to see the applications of things, and that was something I was really struggling with in terms of science in trying to get use to it."

Findings throughout this study indicate that youth participants now have greater interest in learning about environmental science or science in general. Most youth are pursuing learning opportunities on their own through accessing traditional knowledge among community members, leadership opportunities within their school or community, or—in the case of a few—creating their own learning opportunities. The majority of youth realized that learning comes from a desire to further their own education and knowledge, not just to satisfy a requirement. Being involved in the field center program has played a significant role in uncovering this importance and has reinforced the realization that Western science is surrounded with concepts of their culture. Through juxtaposing both Native knowledge and Western science, youth are better prepared to advance their learning environments because they have gained tools to help them think critically. They also apply the knowledge they gained through the field centers to their daily lives. Because the learning experiences are applicable to their surroundings, they remain interested in science learning.

The benefits associated with the NSFC program have been valuable for most participants. The academic benefits have been positive for 100 % of the case study youth. A few youth have been innovative in applying their knowledge to research opportunities in the school setting and are utilizing the research projects to advance their course work. One of

the key outcomes is the feedback youth provide by being able to convey their knowledge in the classroom setting. Often times teaching their teachers about worldviews and contributing to a greater understanding of their peers influenced the role modeling and leadership engagement among these particular youth. All of the students stated that incorporating outdoor learning has challenged them hands on, physically, visually, and mentally more than just having an indoor lecture. Incorporation of outdoor ISE learning increased their sense of well-being and allowed them to become more intimate with their environment. Sixty percent of the students have stated that they are taking upper level courses in either science or mathematics.

In the area of traditional benefits, being involved in the NSFC program helped youth realize the importance of sustaining their cultural knowledge and speaking their traditional languages and encouraged them to keep their learning active. Fifty percent of the youth interviewed in the 2011–2012 supplemental study have taken initiatives to continue their Native language learning outside the field center. Of that 50 %, several have accessed traditional knowledge holders and language speakers or language resource programs. Seventy percent of the case study youth who participated in in-depth interviews have stated that the NSFC program has aided in their development of leadership skills. Part of this thought process stems from the desire to help their community or give back to their community through language and cultural maintenance.

Impacts of NSFCs on students

As demonstrated in the narrative data above, students were significantly impacted by their experiences in the NSFCs in terms of influencing their interest and motivation in science learning and traditional knowledge. This study also shows that the field center programs provided both academic and traditional benefits, as well as leadership opportunities through participation. Some of the documented academic benefits included an increased interest in taking additional science courses in high school, increased interest in a science career, and increased interest in attending college. Traditional benefits were based on several variables such as interest in engaging in traditional community activities, learning traditional stories, learning their traditional language and gathering plants for traditional purposes. Some of the leadership opportunities included internships, mentoring, and training for leadership roles. Quantitative data from the NSFC supplemental study is provided in the "Appendix". Impacts before and after attending the NSFCs were recorded for the 69 seasoned participants who completed surveys. Further qualitative impacts (i.e., traditional benefits) were also recorded in representative quotes from in-depth follow-up interviews (Valdez 2012).

Based on this NSFC evaluation data, Native youth participating in the NSFCs also exhibited greater engagement in science experiences out of school, and higher awareness of traditional uses of plants and animals as a result of participating in these programs. NSFC youth participants learned critical thinking and scientific inquiry skills, the use of modern technologies in scientific data collection, and standards of data collection. These skills and relationships that were fostered with adults helped youth develop confidence to pursue STEM degrees. Additionally, NSFC youth recognized their cultures' contributions to science. The NSFCs documented impacts on youth reflect the strong foundation and the success of the program in providing youth with culturally rich science learning opportunities. These findings indicate that when a student's traditional knowledge and Native language are being honored and recognized as part of informal science education programs, student participation and knowledge gains increase.

What have we learned

Future programs looking to integrate Native ways of knowing and Western science learning may benefit from understanding the obstacles faced, unique elements learned, and associated recommendations from the NSFCs. We recognize that adequately responding to the recommendations may ultimately depend on funding, timing, and the ability to allocate program resources to address them. The unique strategies and activities shared here reflect the innovations of each NSFC as they met and faced challenges along the way. Our education and growth from this project emphasized the significance of community and family participation, of cross-cultural sharing, and of developing a sustainable infrastructure to support the NSFCs as they generated broader impacts for all participants.

As we initially suspected, we found that community and family inclusion is a critical component and should be supported at all stages. The level of concrete commitment demonstrated by the parents and families of participants exceeded our expectations. Parents' commitment to preparing paperwork for initial participants, and then later for their siblings to attend the NSFCs, supported recruitment efforts as well as regular attendance and retention throughout the programs. Through this process we learned the importance of stimulating increased parental support and orienting both parents and students on the importance of retention for learning development during the application process. This allowed us to better engage parents in the NSFC experience for the future education of their children and was key to initiating attendance for weeklong seasonal sessions. Students and parents alike surprised us by how responsive they were during these sessions. Students especially, moved out of their comfort zones enduring challenging weather conditions and extended field days as they learned to grow closer with their environment. We were also impressed by the extensive involvement of Elders and tribal leaders in NSFC communities. Many individuals volunteered their time and donated materials to support the programs. Through their involvement, we learned that including community in the NSFC programs serves to raise local awareness of how cultural processes can benefit the educational systems and allows both youth and adults to learn new concepts together. These lessons also highlight the importance of ensuring that community Elders have opportunities to share their knowledge and experience. We recommend encouraging students to conduct interviews with Elders. These opportunities provide students interviewing skills, teach them the importance of their cultures and lands, and empowers them to help their communities preserve information for future educational use.

Another experience that we learned from was the process of bringing diverse perspectives together for cross-cultural sharing and knowledge exchange. We discovered that in developing methods for cross-cultural sharing, programs can provide a balanced perspective of field experiences by inviting scientists and community members from diverse backgrounds, such as professional Western scientists and traditional knowledge holders. In this process, we found it important to maintain consideration of historical tensions from exploitation around sharing sacred knowledge and cultural stories with non-Natives and even other Native groups.

Our recommendation in this regard is to make clear to all participants—parents, Elders, staff, and students—that the NSFC is a multicultural, shared experience and that knowledge imparted at NSFC events is to be shared cross-culturally so that everyone can learn from one another. When presenting program activities, we found it most effective for NSFCs draw on the Native cultural perspective of a topic first, following up with the Western scientific perspective on what is being discussed.

Throughout this process we identified several further components necessary for supporting a strong and sustainable infrastructure for future programs. At the outset it is important to clarify the protocol, procedure, and approval process from the fiscal agent (or NSFC) to accessing participant records, program documents, and related program histories. We learned that finding staff who are dedicated and devoted, promote respectful relationships, and who are invested in the goals of the NSFC programs' vision/philosophy is also essential to program success. One expectation that was confirmed when developing our programs' infrastructure was the key role that language would hold in the NSFCs. Through the responses of parents and student participants we recognized that Native languages are a powerful piece and therefore recommend prioritizing funding for language from the beginning of the planning stage. When it came to evaluation, we found that programs could train evaluators to craft and tell stories within the context of the NSFCs' goals and objectives. In this process we found it effective to use strategies that focus on what's working and what's unique, and assess the strength-based aspects of the program.

Other features we recognized included reinforcing bridges for students' educational and career paths. We recommend strengthening relationships with tribal colleges and universities to ensure STEM academic and career pathways are accessible for the NSFC youth. At the same time we see a need to continue to educate high school teachers and tribal college and university faculty about culturally relevant science teaching. Seeking continuous support, such as summer internships with the NSFC, National Parks, or other related programs was also identified as a method for supporting students in maintaining their connections to the STEM field. As interest in the NSFC programs increased, we recognized that there may be more need for participant selection criteria. We advise selection criteria be family inclusive and that seasoned participants be invited to take part as mentors in NSFC events. Finally, NSFCs should track individual students as they progress in the educational pipeline. This will help monitor their pursuit of a STEM career, if one is identified.

Beyond the target goals related to student interest in STEM, we observed several secondary results from this study worth noting here. For example, through participation many students and community members become lifelong learners, acquiring more holistic views of not only Western science, but also their own cultural and traditional knowledge. Several adults, Elders, and staff who participated became implementers of community-driven, culturally appropriate STEM programs. They awakened local interest in sharing traditional environmental knowledge. Likewise, after participating in the NSFC, several Elders and cultural leaders went back to school. Some enrolled in the Piikani (Blackfeet) studies program at Blackfeet Community College. Another secondary result from the NSFC projects was a transferring of knowledge between Elders and participants in which rights were given for participants to hold cultural knowledge within their community. These instances of lifelong learning and personal growth opportunities extended to the authors of this study as well. As we shift from oral traditions to embracing multiple outlets for sharing, such as this written study, we reflect on the process of renewal of knowledge as an important piece of our roles as researchers, educators, and practitioners.

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Appendix

See Table 3.

Table 3 NSFC supplemental study

Impacts		Target area	Summary of outcomes
Before-NSFC	After-NSFC		
Interest			
77 %	91 %	Interest in Environmental Science	Analysis indicates a significant (14 %) increase in impacts to student's interest in environmental science
88 %	95 %	Interest in learning about traditional knowledge	Analysis indicates an increase (7 %) in impacts to student's interest in traditional knowledge
81 %	95 %	Interested in learning their traditional language	Analysis indicates a significant increase (14 %) in impact to student's interest in learning their traditional language
35 %	76 %	Learning about areas of science.	Analysis indicates a significant impact (41 %) of students increasing their interest in learning about areas of science as a result of their participation in the NSFC program
Benefits (academic)			
61 %	91 %	Interest in a career in environmental science	Analysis indicates a significant increase (30 %) in student's interest in a career in environmental science through their participation in the NSFC program
84 %	88 %	Interest in attending college	There is a noted increase (4 %) of students interested in attending college as a result of being involved in the NSFC program
64 %	83 %	Interest in taking more science courses	Analysis indicates significant impact (19 %) in student's interest in taking more science courses in high school as a result of their participation in the NSFC program
Benefits (traditional cultural knowledge)			
78 %	90 %	Interest in being involved in community	Analysis indicates a significant impact (12 %) of students interested in being involved in their community as a result of their participation in the NSFC program
81 %	89 %	Interest in engaging in traditional community activities	Analysis indicates an impact (8 %) of students interested in engaging in traditional community activities as a result of their participation in the NSFC program
86 %	91 %	Interest in learning traditional stories	Analysis indicates an impact (5 %) of students interested in learning traditional stories as a result of their participation in the NSFC program
Leadership			
60 %	80 %	Leadership skills strength	Analysis indicates a significant impact (20 %) of students strengthening their leadership skills as a result of their participation in the NSFC program
68 %	83 %	Making scientific observations about the environment	Analysis indicates a significant impact (15 %) of students indicating they are strong at making scientific observations about the environment as a result of their participation in the NSFC program

Statistical Data from NSFC Supplemental Study (Valdez 2012)

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