COSEE-AK Ocean Science Fairs: A Science Fair Model That Grounds Student Projects in Both Western Science and Traditional Native Knowledge

Robin Dublin,[1,a] Marilyn Sigman,[2] Andrea Anderson,[3] Ray Barnhardt,[4] and Sean Asiqluq Topkok[5]

ABSTRACT

We have developed the traditional science fair format into an ocean science fair model that promoted the integration of Western science and Alaska Native traditional knowledge in student projects focused on the ocean, aquatic environments, and climate change. The typical science fair judging criteria for the validity and presentation of the science were expanded to include criteria for cultural and/or community relevance, and local and cultural experts were involved in judging. The Center for Ocean Sciences Education Excellence–Alaska (COSEE-AK) provided support for teachers to organize local and regional fairs and for student and chaperone travel to an ocean science "fair within a fair" at the Alaska statewide science and engineering fair. This approach engaged Alaska Native and rural students in science practice relevant to their cultures and communities and is being sustained by trained teachers and school districts. The results of interviews of 31 of 44 students participating in the 2013 COSEE-AK Ocean Science Fair at the state level suggest learner outcomes of (1) strong, positive feelings of self-efficacy in science; (2) comfort with being identified as a scientist; and (3) feelings of connection to the student's community and support in doing science projects. The ocean science fair can serve as a model for broadening diversity of participation in science by increasing the relevance of science to culture and communities in areas with ethnic groups and/or rural communities that are underserved by science instruction and resources. *© 2014 National Association of Geoscience Teachers*. [DOI: 10.5408/12-411.1]

Key words: science fair, traditional knowledge, culturally responsive science education, self-efficacy, science identity

PURPOSE

How to best broaden participation in science—to engage underserved populations that are underrepresented in science, technology, engineering, and mathematics (STEM) careers—is of increasing interest for science education researchers. The Center for Ocean Sciences Education Excellence–Alaska (COSEE-AK) Ocean Science Fair model was designed as an intentional integration of Western science with traditional cultural knowledge to broaden the participation of Alaska Native and rural students in science and thus prepare them for STEM jobs and careers.

COSEE-AK, the Center for Cross-Cultural Studies at the University of Alaska Fairbanks (UAF) and the Alaska Native Knowledge Network (ANKN) partnered from 2009 to 2013 to promote the engagement of Alaska Native and rural students in local, regional, and statewide science and technology fairs that include traditional Alaska Native and/or otherwise locally relevant knowledge on an equal footing with scientific knowledge. The addition of judging criteria and judges in the area of cultural merit and relevance to the student's community is the key innovation to the typical science fair, one designed to affirm both the students' science learning and the cultural context of the science learning.

COSEE-AK is a consortium of ocean research and education organizations that includes the UAF Center for Cross-Cultural Studies, the UAF School of Fisheries and Ocean Sciences, Alaska Sea Grant, the Alaska SeaLife Center, and the Alaska Ocean Observing System. Nationally, COSEE's mission is to assist ocean scientists in reaching broad audiences with their research. COSEE-AK does this with a thematic focus on "People, Oceans and Climate Change" while weaving Alaska Native knowledge and Western science together. Creating the COSEE-AK Ocean Science Fair is one of multiple strategies being used to address COSEE-AK's thematic focus.

Received 19 December 2012; revised 24 May 2013, 4 August 2013, and 24 October 2013; accepted 26 November 2013; published online 28 May 2014.

[1]Center for Ocean Sciences Education Excellence–Alaska (COSEE-AK), 1009 West 3rd Avenue, Suite 100, Anchorage, Alaska 99501, USA
[2]School of Fisheries and Ocean Sciences/Alaska Sea Grant/Marine Advisory Program, University of Alaska Fairbanks, 1009 West 3rd Avenue, Suite 100, Anchorage, Alaska 99501, USA
[3]Sound View Evaluation and Research, 2837 Northeast 178th Street, Lake Forest Park, Washington 98155, USA
[4]Center for Cross-Cultural Studies, University of Alaska Fairbanks, 124 Bunnell, PO Box 756730, Fairbanks, Alaska 99775, USA
[5]Alaska Native Knowledge Network, University of Alaska Fairbanks, 117 Bunnell, PO Box 756730, Fairbanks, Alaska 99775, USA
[a]Author to whom correspondence should be addressed. Electronic mail: robindublin@coseealaska.net. Tel.: 907-375-1410. Fax: 907-277-5242

CONTEXT

Impacts of Science Fairs on Students

Research focused on the impacts of science fairs on students is lacking, even though these activities have been a stable practice in education since the 1940s (Grote, 1995; Yasar and Baker, 2003; Sonnert et al., 2013). Deeter (1987) focused on the teachers' willingness to do science fairs and their reasons for participating. Other researchers (Grote, 1995; Bunderson and Anderson, 1996) demonstrated that even though teachers lacked science fair experience, the science fair was a worthy activity from their point of view because it provided learning that could not be duplicated in the classroom. Research by Czerniak (1996) and Somers and

Callan (1999), as cited by Carlone and Johnson (2007), indicates that engagement in science competition activities positively correlates with increased student interest in science and potential for engaging in science careers. Other than these few studies noting changes in interest levels, research on the impacts of science fairs on students' knowledge, skills, or behaviors is limited.

During the 1980s and 1990s, a growing interest in equity issues in science engagement resulted in research on science fairs as part of a broader pursuit of multicultural teaching and a concern about increasing the involvement of women in science (Aikenhead and Jegede, 1999; Brickhouse et al., 2000; Yasar and Baker, 2003; Carlone and Johnson, 2007; Sonnert et al., 2013). A number of researchers noted the increased involvement of female students in science fairs (Brickhouse et al., 2000; Sonnert et al., 2013). But others expressed concern that the "culture of science remained most congruent with the white male norm and students face unpleasant conditions" (Seymour and Hewitt, 1997, cited in Carlone and Johnson, 2007). Aikenhead and Jegede (1999) referenced scholarship by Maddock (1981) and Pomeroy (1997) that described school science as a foreign culture to students that "created a cultural clash" between the lives of the students and the aims of Western science.

Traditional Knowledge and Western Science

In the early years of the 21st century, scientists across the world started focusing on the inclusion of local knowledge and traditional ecological knowledge (TEK) into scientific research as a way to engage rural and indigenous communities. In the Arctic, in particular, the presence of indigenous people provided an approach to better manage resources through increased understanding of the changes in conditions that could be contributed by long-term observers (Alexander et al., 2011). While this approach was not without the criticism that science is "universal" while indigenous knowledge is place based (Cobern and Loving, 2000), a significant number of social and natural scientists have reached philosophical and scholarly accommodations toward the integration of TEK and Western science (Huntington, 2000; Gagnon and Berteaux, 2006; Oakes and Riewe, 2006; Tremblay et al., 2006; Carter, 2008; Gagnon and Berteaux, 2009). Many science education researchers have come to a similar understanding about the need to integrate the worldviews of Native American and Alaska Native students with the nature and practice of science. These researchers argue that education must help students navigate between the culture of their everyday life and the culture and accepted practices of Western modern science (Semken, 2005; Aikenhead, 2011). Yet most acknowledge that additional research in this area is needed (Kawagley, 1993, 1995; Kawagley et al., 1998; Cobern and Loving, 2000; Snively and Corsiglia, 2001; Barnhardt and Kawagley, 2005; Semken, 2005; Hurtado et al., 2008; Aikenhead, 2011).

Creating Science Identity Through Place-Based and Culturally Responsive Education

Education researchers acknowledge that students establish social identities and role identities through interactions with family, community, peers, and teachers (Twigger-Ross and Uzzell, 1996; Stets and Burke, 2000). Identity is a way that individuals exist within the world—experiences with events and relationships that inform thoughts and actions. The "place" and the "culture" from which students come when they arrive at school help frame the student's identity (Kozoll and Osborne, 2006; Michell et al., 2008). Researchers in science education consider science literacy important for youth from underserved populations who are disproportionately impacted by persistent environmental issues (Tzou et al., 2010). The National Research Council's publication, *A Framework for K–12 Science Education* (National Research Council, 2012) places strong emphasis on cultural assets and cultural context as important aspects of equity in science education. Yet among indigenous populations, this deep-rooted cultural identity may occasionally conflict with the practices and culture of science as presented through school curriculum (Kawagley, 1993; Cobern and Aikenhead, 1997; Lemke, 2001; Hurtado et al., 2008; Aikenhead, 2011; Kuwahara, 2013).

Place-based and culturally responsive education provides an approach that supports Alaska Native students in crossing boundaries between their indigenous culture, TEK, and native ways of knowing and the practices and knowledge of science (Kawagley and Barnhardt, 1998; Kawagley et al., 1998; Snively and Corsiglia, 2001; Gruenewald, 2003a, 2003b; Kozoll and Osborne, 2004, 2006; Ellis, 2005; Semken, 2005; National Research Council, 2012; Kuwahara, 2013; Tsurusaki et al., 2013).

Alaska's Indigenous Peoples, Traditional Knowledge, and Culturally Responsive Science Education

Alaska has a rich, diverse, and complex indigenous population that includes six distinct cultural regions. The indigenous peoples in these regions—Iñupiat, Yup'iit/Cup'iit, Athabascan, Aleut, Alutiiq, and Southeast (Tlingit, Tsimshian, and Haida)—are collectively referred to as Alaska Natives. The cultural nuances, unique experiences, and traditional native knowledge, skills, and ways of knowing encompassed by this term go far beyond the scope of this article, but it is crucial to recognize the depth and breadth of knowledge that exists within the whole of these cultural traditions and within each cultural community.

Alaska Natives are collectively Alaska's largest minority population. The postcontact history of governmental and educational policies left a legacy that continues to negatively influence the quality of education in Alaska Native communities. Today, in 53 school districts spanning 1,718,000 km^2 (663,300 mi^2), Alaska Native students struggle to succeed in school, and Alaska is ranked 39th in high school preparedness for college (National Education Association, 2011). Alaska Native students rank consistently lower than other ethnic groups in annual standardized testing. Several factors contribute to low academic achievement by Alaska Native students. Teacher turnover, a chronic issue in the state, averages 12% annually overall and rises to as much as 60% in rural schools (Hill et al., 2013), exacerbating challenges for Alaska Native students. Alaska Native students make up 24% of the student population, but only 5% of teachers in Alaska are Alaska Natives (Alliance for Excellent Education, 2008). Teachers who stay in their community long enough to learn how to teach in a culturally responsive manner are rare, and limited exposure to Alaska Native teachers exacerbates cultural challenges for Alaska Native students.

The ocean science fair model described within this paper is an application of research on culturally responsive science

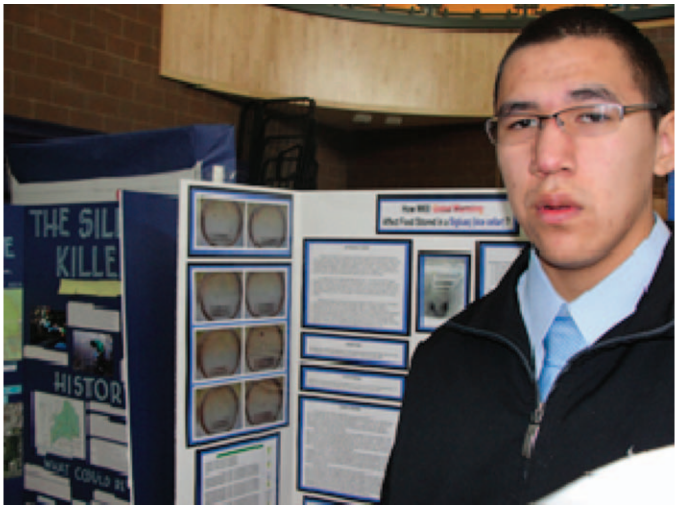

FIGURE 1: Phillip Sittichinli from Barrow High School, 2010 ocean science fair winner, posed the following question: Will a 3°C temperature increase affect bacterial growth on *muktuk* (whale blubber) and whale skin in *insiqluaq* (ice cellars)? *Insiqluaq* are traditionally used to store subsistence foods. Sittichinli was concerned about the potential impacts of climate change on this tradition.

education (Aikenhead, 1997, 2001; Stephens, 2001; Barnhardt and Kawagley, 2010). Ocean science fairs uniquely address the circumstances faced by students in Alaskan rural communities, where everyday life depends on the traditional knowledge held by Alaskan Elders and the pragmatic usefulness of scientific understandings (Dick, 2010). The requirement to integrate cultural relevance and sound science practices in ocean science fair projects is an authentic reflection of current practices among many Arctic and ocean researchers (Riedlinger and Berkes, 2001).

The science fair model was developed by the ANKN, an outgrowth of the Alaska Rural Systemic Initiative (AKRSI), which began in 1994, with an emphasis on improving educational opportunities for Alaska Native students, particularly in rural communities. The program had an emphasis on STEM fields long before they were referred to as STEM. Rural science fairs were one of several strategies implemented by AKRSI that positively influenced student performance. In its first 5 y, the AKRSI strategy produced increases in student achievement scores, the number of rural students attending college, and the number of Alaska Native students choosing to pursue studies in the fields of science, math, and engineering. This effort also decreased dropout rates in Alaska (Barnhardt and Kawagley, 2005). These efforts have, over time, increased the number of Alaska Native students who, while well grounded in their traditional native culture, are seeking degrees and careers in STEM fields (Barnhardt and Kawagley, 2010).

In this article, the term "traditional knowledge," referred to in the social science literature as TEK (International Program on Traditional Ecological Knowledge, 1993), is used instead of TEK, because ecology is only a component of the cultural context related to everyday survival skills and practices that have an aspect of STEM education (Fig. 1). Integration of traditional knowledge into science education in Alaska is a means to implement the evidence-based approach of science learning as a cultural accomplishment highlighted in the Next Generation Science Standards Framework (National Research Council, 2012).

METHODS

In 2009, the ANKN and the associated UAF Center for Cross-Cultural Studies became partners in COSEE-AK. They adapted their existing science and engineering fair model to focus on topics specific to the ocean, freshwater environments, and climate change, and they formally institutionalized the COSEE-AK Ocean Science Fair as a "fair within a fair" within the statewide Alaska Science and Engineering Fair held in Anchorage. Table I shows the annual planning calendar that was necessary to organize participation in the COSEE-AK Ocean Science Fair. During the period 2009–2012, COSEE-AK provided training and financial support to 14 of Alaska's 53 school districts to promote the organization of local and regional ocean science fairs and to help fund student and teacher travel to the statewide fair from rural communities.

Training and Materials

The UAF Center for Cross-Cultural Studies and COSEE-AK developed materials and a daylong training session aimed at rural science teachers and district science curriculum specialists. To focus attention and travel across such a large and diverse state, one cultural region was targeted each year. Teachers and curriculum specialists were invited to the training with funding support from the National Science Foundation–funded COSEE-AK project (see the appendix). The *COSEE Manual for Science Camps, Fairs and Projects* (Dick, 2010), the videos *To Show What We Know* and *Science Fairs Are Fun* (ANKN, 2000a, 2000b), and a presentation on the role of indigenous knowledge in science education were discussed, in addition to a thorough review of judging criteria. Additional resources, planning outlines, and the brainstorming process for projects were also covered.

Following the training session, teachers and curriculum specialists returned to their communities and worked with students to identify projects that were culturally and/or locally relevant. The differentiation between culture and local was made because some students in Native Alaskan villages have limited access to Alaska Native Elders and other culture bearers and organizers thus thought that the broader emphasis avoided excluding interested students. The differentiation between an Elder and a culture bearer is most often one of age and recognized cultural expertise. Alaska Native respect for their Elders is paramount, and the designation of "culture bearer" recognizes that younger community members also teach through role modeling and creating opportunities for learning.

Teachers and curriculum specialists supported students as they developed their projects. COSEE-AK Ocean Science Fair projects were required to relate in some direct way to the ocean, freshwater environments, or climate change. This resulted in projects related to geoscience concepts in disciplines such as oceanography, atmospheric sciences, hydrology, and water chemistry. Students were allowed to develop team projects in accordance with rules for the Alaska Science and Engineering Fair.

TABLE I: COSEE-AK Ocean Science Fair annual planning calendar.

Month	Activity
August	Plan for regional fairs and conferences, and outline other yearlong tasks.
	Promote through culture and science camps, science centers, local and regional aquaria, and science clubs.
September	Begin monthly statewide fair planning committee meetings.
	Promote participation with science curriculum specialists and teachers, and invite them to participate in training.
October	Promote to teachers at Alaska Science and Math Conference.
	Promote participation with science curriculum specialists and teachers, and invite them to participate in training.
November	Promote at Alaska's Bilingual Multicultural Education Equity Conference, and recruit cultural judges.
	Begin regional fairs; run regional fairs through May.
December	Prepare to promote at the Alaska Marine Science Symposium (occurs in January).
January	Hold training face-to-face or webinar for science curriculum specialists and teachers.
	Recruit science judges at the Alaska Marine Science Symposium.
	Continue regional fairs.
	Provide support to teachers and science curriculum specialists for prestatewide fairs.
	Plan travel support for judges, students, and chaperones.
February	Provide support to teachers and science curriculum specialists for prestatewide fairs.
	Make final registration decisions, confirm judge travel and honorarium, student travel, and chaperone travel to the statewide fair.
	Promote the science fair at Alaska Forum on the Environment student programs for next year.
	Continue regional fairs.
	Set up logistics for distance delivery of posters (Skype or videoconferencing) for students who cannot travel.
March	Organize last-minute logistics, including prizes and certificates.
	Undertake judging and awards at the Alaska Science and Engineering Fair in Anchorage.
April	Celebrate student success (letters for students, local media pieces, paperwork for cash prizes, etc.).
	Complete remaining regional fairs.
	Plan summer culture and science camps, and send promotional materials to science centers and local aquaria.
May	Evaluate program successes and areas for improvement.
June	Promote through culture and science camps, science centers, local or regional aquaria, and science clubs.
July	Promote through culture and science camps, science centers, local or regional aquaria, and science clubs.

Judging

Scientific and cultural judges at local and regional fairs were selected from the community—scientists to judge the scientific merit of the project and Alaska Native Elders, other culture bearers, or culturally responsive science educators to judge the project's cultural merit. At the state fair, culture bearers and native educators were invited to be judges, along with educators from the ANKN and COSEE-AK. The judges reviewed any project in the overall fair that addressed the oceans, freshwater environments, and/or climate change. In addition, the judges evaluated projects that were not related to these three topics but instead addressed culture. They moved through the fair, interviewing students about their projects. Recognizing that this may be their first experience in the fair setting, the judges often prompted students for more information.

The judging criteria were provided on four forms. Students were judged using one of three Western science score sheets for different types of science projects, in addition to a score sheet that assessed traditional knowledge and/or relevancy to culture or community (COSEE-AK, 2012). Scientific judging sheets were developed for observation, collection, and experimental projects, with rubrics for each project type. Table II compares the judging categories for each type of project; the rubrics for observation, collection, and experimental projects are provided as supplemental materials (see Supplemental Materials for the detailed rubrics; available at http://dx.doi.org/10.5408/12-144s1). As shown in Table III, the rubric for judging traditional native knowledge and/or community relevancy included the categories of cultural values, quality of the project, importance, and community resources (Fig. 2). If the inclusion of traditional native knowledge was not the appropriate criterion (e.g., the student or students were not Alaska Native or the community was not predominantly Alaska Native), then the community relevance of the project topic was considered instead.

In the criteria for judging traditional knowledge and/or cultural or community relevance, students were evaluated on how clearly their project was tied to their community's culture, activities, resources, science-related issues, or concerns. While students were not required to engage Elders, other culture bearers, or local experts in their project, they received higher overall scores if they did so.

TABLE II: COSEE-AK Ocean Science Fair rubric categories for judging scientific merit of different types of science projects.

Rubric Categories		
Observation	Collection	Experimental
Creativity, originality	Originality, theme	Creativity, originality, theme
Appearance	Appearance	Appearance
Data	—	Data
Presentation	—	Presentation
Quality/variety	Purpose	Scientific process
	Variables	Conclusions
	Research	Use of materials
	Observation skills	
	Recording skills	

[1]Projects are scored with 1, 3, or 5 points in each category, with the exception of the scientific process criterion, which is scored 2, 5, or 10 points.

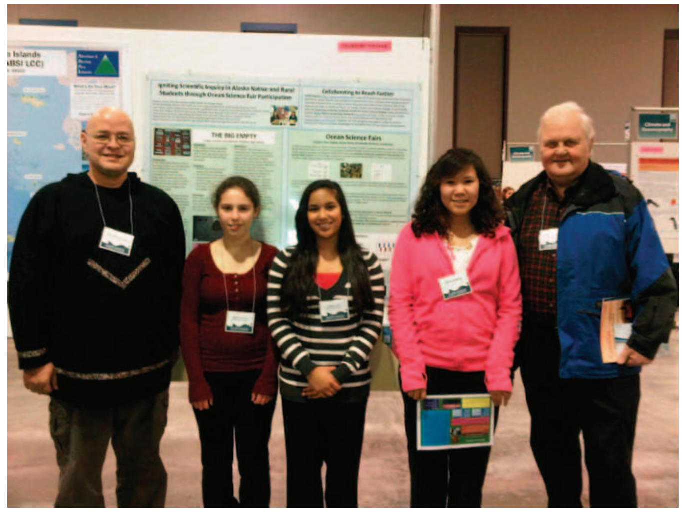

FIGURE 2: Sean Asiqluq Topkok (ANKN), China Kantner (Kotzebue High School), Ember Eck (Kotzebue High School), Molly Adams (Barrow High School), and Ray Barnhardt (UAF Center for Cross-Cultural Studies). Photo by Robin Dublin (COSEE-AK) at the 2012 Alaska Marine Science Symposium poster session.

Awards

Awards were presented in three categories: science, traditional knowledge, and a combined category. Students competed by grade level. Awards were in the form of cash, science and natural history books, outdoor gear, and free passes for aquarium visits.

Travel Logistics

The logistics of getting teams of two or more students and their chaperone from six to nine remote villages to Anchorage, Alaska, each year required considerable coordination. All of the communities were remote and inaccessible by road. With National Science Foundation grant support, COSEE-AK provided the travel funding for students during the fairs in 2009–2012. For the 2013 Alaska Science and Engineering Fair, funding for travel for COSEE-AK Ocean Science Fair participants typically came from the school district or family members.

Evaluation

To evaluate the participation of Alaska Native and rural students in the ocean science fairs, we relied on demographic information about the students' schools and communities. Ethnic information was available at the school level but not for individual students for reasons of confidentiality.

To gather data on the impact on students of their participation in ocean science fairs, we interviewed COSEE-AK Ocean Science Fair participants during the 2013 Alaska Science and Engineering Fair (Fig. 3). Prior science fair research has focused on understanding of scientific methods, attitudes toward science, differences in participation and accomplishments based on gender, and connection of the science fair with classroom skill development (Lawton and Bordens, 1995; Schneider and Lumpe, 1996; Yasar and Baker, 2003; Sonnert et al., 2013). By contrast, we sought to address learner outcomes that are the focus of current science education research but have not been studied in science fair participants (Twigger-Ross and Uzzell, 1996; Cobern and Aikenhead, 1997; Gee, 2000; Kozoll and Osborne, 2004; Carlone et al., 2008). The interview protocol was designed to gather formative data (i.e., baseline information) on students' perceptions of science identity, their cultural connection, their support from teachers and/or community and family, their perceptions about self-efficacy, and their future interests in science engagement. We hypothesized that those doing ocean science fair projects would have positive feelings of self-efficacy, would have strong cultural connections, would develop or increase identification with science, and would enjoy the recognition of family, friends, and teachers for their science work.

Based on our prior experience with ocean science fair participants, we developed an interview protocol that was

TABLE III: COSEE-AK Ocean Science Fair rubric categories and criteria for judging traditional knowledge and/or cultural or community relevance.

Rubric Category	Criterion
Cultural values	The presentation by the students and display of their project maintains the cultural values of their area.
Project quality	The student's work is well done. The project is organized and attractive. It shows good thought. The presentation is clear and confident. The discovery process is clearly used in village or community life.
Importance	The project is a study of something that is important to the land, village, or community.
Community resources	There is clear evidence that the student consulted with one or more community Elders or local experts or consulted other cultural resources.

[1]Each project was scored as needs more work (1 point), good (3 points), or excellent (5 points).

FIGURE 3: China Kantner and Ember Eck of Kotzebue High School with their ocean science fair poster.

simple to administer and would not unduly distract the students during their required presentation to the science fair judges. The interviewers took notes during the interviews rather than using a recorder, because earlier attempts to make recordings were rendered inaudible by the ambient noise.

The interview protocol included nine Likert-type scale items (ranging from 1 = strongly disagree to 10 = strongly agree) and five open-ended response items, which were adapted from existing survey instruments that correspond to our outcomes of interest (Roth and Li, 2005; Cole, 2012). As shown in Table IV, the Likert-type scale items were designed to elicit responses about perceived self-efficacy, science identity, and community connection and support. The open-ended response items addressed (1) how students selected their research question; (2) the kind of support students received from teachers, scientists, and family or community members; (3) whether students had competed within their school district for a chance to attend or they had self-selected to participate in the Alaska Science and Engineering Fair; (4) the students' plans following high school; and (5) whether the project had an influence on those plans.

Four individuals interviewed the students, who ranged in age from elementary to high school. Each interviewer was assigned a random set of posters to review and conducted an interview with the presenter. For some of the posters, a team of students had completed the investigation. The interviewer was given discretion to interview one or both of the team members. The interviewers were also asked to write comments if they observed or noted anything while talking with the student that might be helpful in better understanding the student's (or team's) science fair experience.

The interviewers met together to debrief about the data collection process following the event, noting difficulties and insights about the process. The data, including interviewers' written notes and scale scores, were compiled. The data from the scaled responses were analyzed for descriptive statistics. The written notes for the open-response questions were coded for themes that might illuminate the results of the scaled items or might be useful in future research.

RESULTS

Ocean Science Fairs Draw Alaska Native and Rural Students

In 2013, 41 students submitted a total of 32 posters representing 20 schools and one homeschooled student. The ethnic composition of each school is shown in Table V, based on data about ethnicity available through public sources such as Web sites of individual schools and of the Alaska Department of Education and Early Development. Among the schools represented at the 2013 COSEE-AK Ocean Science Fair, eight schools in seven rural communities and in Anchorage had Alaska Native student populations of more than 50%, compared with 10 schools in two communities (nine of them in Anchorage) where students were predominantly white and one school, Unalaska, where

TABLE IV: Student response rates for scaled-item questions (categorized by outcomes).

Scaled Items Included in Interview Protocol	Outcome Category	Respondents by Level of Agreement-With Statement (%)									
		Strongly Disagree								Strongly Agree	
		1	2	3	4	5	6	7	8	9	10
I think doing the Ocean Science Fair project was fun.	Self-efficacy	0	0	0	3	0	0	13	25	9	50
I would like to do this kind of project again.	Self-efficacy	3	0	3	3	6	3	6	9	6	62
I think doing this kind of project is hard.	Self-efficacy	3	3	6	9	3	13	19	13	16	16
My family (or legal guardians) would be happy if I decided to pursue a career in science.	Identity	0	0	0	0	9	6	6	9	6	58
My teacher thinks I could be a good scientist one day.	Identity	0	0	6	0		3	13	9	19	31
My friends think of me as a scientist.	Identity	9	6	0	3	16	9	9	9	9	28
I am comfortable thinking of myself as a scientist.	Identity	0	0	0	9	12	9	9	15	6	39
I take part in cultural practices of my ethnic background, such as special food, dance, music, or customs.	Connection and support	12	4	4	0	4	0	4	8	4	36
I got a lot of help and support in doing this project.	Connection and support	0	6	0	6	9	3	6	12	15	42

TABLE V: Proportion of Alaska Native students in schools with students participating in the 2013 COSEE-AK Ocean Science Fair at the Alaska Science and Engineering Fair.

School	Community	Alaska Native Students in School (%)
Kotlik School	Kotlik	100
Pilot Station School	Pilot Station	98
Noatak (Napaaqtugmiut) School	Noatak	94
St. Mary's School	St. Mary's	93
Bethel Middle School	Bethel	81
Mt. Edgecombe High School	Sitka	81
Barrow High School	Barrow	61
Alaska Native Cultural Charter School	Anchorage	52
Unalaska City School District	Unalaska	15
Tanaina Elementary	Wasilla	12
Romig Middle School	Anchorage	11
Klatt Elementary	Anchorage	9
Mears Middle School	Anchorage	9
Rabbit Creek Elementary	Anchorage	8
Central Middle School	Anchorage	6
Goldenview Elementary	Anchorage	6
Rogers Park Elementary	Anchorage	5
Polaris Charter School	Anchorage	4
Aquarian Charter School	Anchorage	1
Pacific Northern Academy	Anchorage	NR
Homeschooled student	Anchorage	NA

[1]NA = not applicable; NR = no report.

students were predominantly Asian (32.3%) and white (39.5%) (available at http://www.biggestuscities.com/demographics/ak/unalaska-city-school-district [accessed 17 February 2014]). Six of the schools with a majority of Alaska Native students were in small, rural villages, and two were schools with a focus on Alaska Native culture in larger communities that were not predominantly Alaska Native. Prior to the inclusion of the COSEE-AK Ocean Science Fair, representation by rural and/or native communities in the statewide fair was minimal. According to Texas Gail Raymond, the Alaska Science and Engineering Fair coordinator, rural student participation was substantially higher during 2009–2012, an increase she attributed to the ocean science fair program (Raymond, pers. comm., 2012).

Interviews Reveal Discernible Science Identity, Self-Efficacy, and Strong Intentions to Pursue Further Science Study

Interview data were obtained for 34 of the 41 students who submitted a poster for the ocean science fair. Fourteen (41%) of the 34 students interviewed were from schools where Alaska Native students composed greater than 50% of the student body.

As mentioned previously, scaled items provided data for three outcomes of concern: self-efficacy, science identity, and community connection and support. Table IV shows the percentage of respondents at each level of agreement per scaled item. The evidence suggests that participants (1) have strong, positive feelings of self-efficacy in science, (2) are comfortable with being identified as a scientist, and (3) feel connected to their community and supported in doing ocean science fair projects.

Ocean Science Fair Participants Have Strong, Positive Feelings of Self-Efficacy in Science

Science identity involves competent performance in science, as well as recognition by others as a science person (Carlone et al., 2008). As learners become more confident and competent in what they know and can do, perceived efficacy increases, as does the students' connection with a community of practice (Bandura, 1977; Boaler et al., 2000; Williams and George-Jackson, 2011; Varelas et al., 2012). For purposes of the interview protocol, we constructed self-efficacy scales using the method of Bandura (2006) that was appropriate for inquiry science, which assumes that being able to do the work, being engaged by the work, and being persistent even if the project is difficult are characteristics of high self-efficacy. The results showed that about three-quarters of the respondents strongly agreed (i.e., rating scores of 8 or greater on the 10-point scale) that the projects were fun and that they would willingly do them again. This response was despite the projects being strongly considered "hard work" by approximately half the respondents.

Ocean Science Fair Participants Are Comfortable With Being Identified as a Scientist

A science identity is deeply connected to the recognition by self and others that behavior, skills, and knowledge are coherent with that particular community of practice (Carlone and Johnson, 2007). Four scaled response items addressed the issue of recognition, as noted in Table IV. Nearly two-thirds of respondents rated recognition by self, teachers, and family members between 8 and 10. Slightly fewer respondents (46%) gave equivalent rating scores about their friends' view of them as scientists. These data indicate participants in the COSEE-AK Ocean Science Fair felt recognized for their science involvement.

Participants Feel Connected to Their Community and Supported in Doing Ocean Science Fair Projects

The interview included a question about student participation in cultural practices related to ethnic background. For 24% of the respondents, the question was not applicable, while 40% of the students gave the question a 9 or 10 rating. Although we did not query students about ethnicity directly and no ethnic information was available on individual students, we observed that students from schools with a high percentage of Alaska Native students were more likely to give higher ratings in response to the question about participating in cultural events. In free response to open-ended questions, we found that community concerns drove several research projects. The following are examples of student responses:

- A student from Kotlik [a school with 100% Alaska Native population], was taken by her father to the traditional fishing site for the village members. The

student had some concerns about the water quality in the area where she lives—there was evidence of environmental issues increasing ice melt, which enhances ocean acidification. She got into figuring out the different locations where water quality might be impacted by metallic ions [in the rural area]. This caused her to wonder about summer boating [recreational] versus hunting and fishing [by community members]. She wanted to understand the impacts, especially during winter.
- A student from the Yukon-Kuskokwim Delta in the Bering Sea became concerned about the local dumpsite for the village, which is in a bad location. Not everyone in the community recycles. She got worried about batteries and cell phones being dumped in the site that is upriver from the village [and right next to the water]. The impact of such dumping could hurt the salmon industry, which provides for the people in the community.

More than two-thirds of respondents (69%) strongly indicated they had received positive support for doing their project. In response to open-ended questions, students described how parents and siblings provided encouragement and sometimes technical support for accomplishing the project. Students garnered advice and guidance from their teachers (13 responses) and community members, including family members (15 responses), scientists (5 responses), village Elders (2 responses), and others (5 responses). We found, in general, that "support" meant providing transportation to data collection sites or contributing equipment to conduct the experiments.

Most Students Plan to Study Science in College

Nineteen of the 34 students interviewed had definitive plans to attend college and study science or engineering. A few more are considering science as an option but are undecided at this point. Several of the students also commented that they would like to return to their community following college and work for the betterment of the village as doctors or environmental advocates.

LIMITATIONS

Several caveats to the findings based on the results of the interviews exist. First, this study was intended as an internal formative evaluation to establish baseline information about students participating in the program. Hopefully, the results may prompt further research, but these findings cannot be assumed to have generalizability to other science fair programs or underserved populations. The interview sample size of 34 students is small relative to the total number of students who participated in regional and district ocean science fairs across the state. Participants in the Alaska Science and Engineering Fair included the winners or first runners-up of the school or district ocean science fairs. These students were sent as representatives of their communities. Presumably, some winners of district fairs were unable to attend. Students also had the option of registering for the state science fair on their own, as many Anchorage and homeschooled students did, without any prior scientific or cultural review by the judges. Those who attended and were interviewed by the team may not reflect the larger population of students who participated in ocean science fairs.

Although we interviewed a majority of students participating in the 2013 COSEE-AK Ocean Science Fair category at the Alaska Science and Engineering Fair, we have limited demographic data about the students, no records of their course work or prior experiences, and no comparison or control group. We do have evidence from these participants of strong science identity and sense of self-efficacy. However, we cannot tell whether the students who participated in the ocean science fair presentations gained their science identity from this particular experience. An alternative explanation would be that students who already have a strong science identity and sense of self-efficacy successfully participate in the state science fair, so in this case, the experience would have reinforced rather than created these qualities.

In addition, the ocean science fair category, and therefore the resultant interviews, was not limited to Alaska Native students. Alaska Native points of view and histories are common threads woven throughout Alaska's curriculum, and we anticipated that the cultural component for the posters would frequently reflect that perspective. However, Alaska has students from many cultures, and we found students aligning their science investigations to their cultural heritage. For example, two students addressed their research from the perspective of their Filipino culture. We also found nonnative students from larger communities focused on projects of relevance to their community even if they were not focused to a particular cultural group.

IMPLICATIONS

The COSEE-AK Ocean Science Fair program revived a village science fair model (Dick, 1997), which combined traditional science with Western science and was among the successful strategies for improving rural science education during the AKRSI (Barnhardt and Kawagley, 2010). We expanded the model to culminate in student participation in the statewide "fair within a fair" and focused it on science related to the ocean, aquatic environments, and climate change.

The ocean science fair program encouraged Alaskan students, and especially those of Alaska Native ethnicity, to conduct science investigations that were simultaneously ocean focused and reflective of traditional or cultural values. Evaluation of learner outcomes from the ocean science fair experience contributed to current research around the development of science identity and the contributions of place-based, culturally relevant learning experiences. Until now no effort had been made to discern whether any aspect of science identity (including self-efficacy or recognition by others) is detectable among those who participate. The results obtained from student interviews during the 2013 COSEE-AK Ocean Science Fair suggest participants have positive feelings of science self-efficacy (i.e., strong confidence in knowing and being able to do science), are comfortable being identified as a scientist, and have deep cultural and community connections, which are important to students doing these place-based investigations. All but two students we interviewed intended to attend college, with most intending to pursue science.

The ocean science fair model contributed to broadening participation in the science practices of observing, classifying, conducting investigations, and communicating hypotheses, results, and conclusions. During the period 2009–2012, the program was responsible for increasing the participation of students from schools in small, rural communities, many of whom were predominantly Alaska Native, in the Alaska Science and Engineering Fair. Participation by these schools before 2009 had been minimal (Alaska Science and Engineering Fair, unpublished data).

The program is being sustained as an annual tradition by school districts and trained teachers. In 2013, COSEE-AK and the UAF Center for Cross-Cultural Studies successfully encouraged schools to seek sponsorships for students and their chaperones from communities, organizations, and local businesses. The COSEE-AK Ocean Science Fair participants at the 2013 Alaska Science and Engineering Fair included students from school districts and schools that COSEE-AK had previously supported with training and financial support for travel.

The results of the student interviews provide evidence that a science fair experience that integrated traditional, culturally relevant knowledge with Western science effectively engaged the students in science. The state science fair experience was likely transformative for many students, particularly in terms of communicating about their science projects. For some participants, this was their first trip to Anchorage, Alaska's largest community and home to half the state's population. For most, it was also their first time participating in a large-scale competition where students are asked to speak directly, with volume and an outgoing confidence, to strangers. For Alaska Native students, this practice is counter to their traditional communication practices.

This model provides a strategy for supporting students in engaging in science practice in the context of their place-based and cultural connections to the geosciences, which is broadly applicable to other cultural contexts and especially relevant to the engagement and achievement of minority students. A recent study revealed concern among scientists that minority students are often compelled to pursue medical careers because they feel it is the only way of contributing to the community (Anderson et al., 2012). For the geosciences, in particular, ocean science fairs can be an effective venue to broaden students' perspectives about research and ways to "give back" to their communities. Students responded strongly about the importance—to them—of returning to their home district after completing college to contribute to the community. For example, one of the students from a school with a high percentage of Alaska Native students said she plans to attend Stanford University and major in environmental engineering (resource engineering) and that she is interested in becoming a politician so that she can represent her district and help the people in her community.

The ocean science fair can serve as a model for culturally responsive science instruction with other cultural groups and in areas with rural communities that are underserved by science. In particular, modifying the scoring and materials to be applicable to Native American and Native Hawaiians in areas of high concentration areas would require a small investment of time and funding. The model can also be easily adapted to include any subject within the geosciences or natural sciences. Additional research on changes in self-efficacy and science identity in connection with place-based, culturally responsive science fairs could increase understanding about the impacts of the model on students and better establish the potential for this model to broaden participation in science.

References

Aikenhead, G.S. 1997. Toward a first nations cross-cultural science and technology curriculum. *Science Education,* 81(2):217–238.

Aikenhead, G.S. 2001. Integrating Western and aboriginal sciences: Cross-cultural science teaching. *Research in Science Education,* 31(3):337–355.

Aikenhead, G.S. 2011. Towards a cultural view on quality science teaching. *In* Corrigan, D., Dillon, J., and Gunstone, R., eds., The professional knowledge base of science teaching. New York: Springer, p. 7–23.

Aikenhead, G.S., and Jegede, O.J. 1999. Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching,* 36:269–287.

Alaska Native Knowledge Network (ANKN). 2000a. *Science Fairs Are Fun*. Fairbanks, AK: ANKN. DVD. Available at http://www.ankn.uaf.edu/publications/ (accessed 17 February 2014).

Alaska Native Knowledge Network (ANKN). 2000b. *To Show What We Know*. Fairbanks, AK: ANKN. DVD. Available at http://www.ankn.uaf.edu/publications/ (accessed 17 February 2014).

Alexander, C., Bynum, N., Johnson, E., King, U., Mustonen, T., Neofotis, P., and Shadrin, V. 2011. Linking indigenous and scientific knowledge of climate change. *BioScience,* 61(6):477–484.

Alliance for Excellent Education. 2008. American Indian and Alaska native students and U.S. high schools. Available at http://www.all4ed.org/files/AmerIndianAKNative_FactSheet.pdf (accessed 17 February 2014).

Anderson, A., Dorph, R., Kwon, P., Chung, J., Canady, M., and Plude, D. 2012. COSEE's influence on scientists' professional practices: Findings from the COSEE scientist study. Available at http://www.cosee.net/files/coseenet/2012_NSF_Sci_Study_Exec_Summary.pdf (accessed 17 February 2014).

Bandura, A. 1977. Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review,* 84(2):191.

Bandura, A. 2006. Guide for constructing self-efficacy scales. *In* Pajares, F., and Urdan, T., eds., Self-efficacy beliefs of adolescents. Charlotte, NC: IAP, p. 307–337.

Barnhardt, R., and Kawagley, A.O. 2005. Indigenous knowledge systems and Alaska Native ways of knowing. *Anthropology and Education Quarterly,* 36(1):8–23.

Barnhardt, R., and Kawagley, A.O. 2010. Culture, chaos and complexity: Catalysts for change in indigenous education. *In* Barnhardt, R., and Kawagley, A.O., eds., Alaska Native education: Views from within. Fairbanks, AK: ANKN, p. 199–218.

Boaler, J., Wiliam, D., and Zevenbergen, R. 2000. The construction of identity in secondary mathematics education. Available at http://eprints.ioe.ac.uk/1142/1/Boalertheconstructionofidentity.pdf (accessed 17 February 2014).

Brickhouse, N.W., Lowery, P., and Schultz, K. 2000. What kind of a girl does science? The construction of school science identities. *Journal of Research in Science Teaching,* 37(5):441–458.

Bunderson, E., and Anderson, T. 1996. Pre-service elementary teachers' attitudes toward their past experience with science fairs. *School Science and Mathematics,* 96(7):371–377.

Carlone, H., Cook, M., Wong, J., Sandoval, W.A., Barton, A.C., Tan, E., and Brickhouse, N. 2008. Seeing and supporting identity development in science education. Paper read at Proceedings of the 8th International Conference for the Learning Sciences, vol. 3. Pittsburgh, PA: International Academy of Learning Sciences, p. 1–7.

Carlone, H., and Johnson, A. 2007. Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching,* 44(8):1187–1218.

Carter, L. 2008. Recovering traditional ecological knowledge (TEK): Is it always what it seems? *Transnational Curriculum Inquiry,* 5(1):17–23.

Center for Ocean Sciences Education Excellence–Alaska (COSEE-AK). Ocean Science Fair judging sheets 2012. Available at http://www.coseealaska.net/programs/oceansciencefairs/resourcesforfairs/ (accessed 17 February 2014).

Cobern, W.W., and Aikenhead, G. 1997. Cultural aspects of learning science. National Association for Research in Science Teaching. Chicago, IL: Western Michigan University Scholar Works.

Cobern, W.W., and Loving, C.C. 2000. Defining ''science'' in a multicultural world: Reconsidering science learning. *Science Education,* 85:50–67.

Cole, S. 2012. The development of science identity: An evaluation of youth development programs at the museum of science and industry. Chicago, IL: Loyola University.

Deeter, B.C. 1987. A survey of science fairs in school district 36 (Surrey) [Ph.D. thesis]. Vancouver, Canada: University of British Columbia.

Dick, A. 1997. Village science, teacher's and student editions. Available at http://ankn.uaf.edu/publications/VS/toteacher.html (accessed 17 February 2014).

Dick, A. 2010. Dealing with accelerating change: The COSEE manual for science camps, fairs and projects. Fairbanks, AK: Centers for Ocean Science Education Excellence–Alaska.

Ellis, J. 2005. Place and identity for children in classrooms and schools. *Journal of the Canadian Association for Curriculum Studies,* 3(2):55–71.

Gagnon, C.A., and Berteaux, D. 2006. Integrating Traditional and Scientific Knowledge: Management of Canada's National Parks. Quebec City, Canada: ArcticNet. Available at http://ebookbrowse.com/gagnon-and-berteaux-pdf-d155889946 (accessed 17 February 2014).

Gagnon, C.A., and Berteaux, D. 2009. Integrating traditional ecological knowledge and ecological science: A question of scale. *Ecology and Society,* 14(2):26.

Gee, J.P. 2000. Identity as an analytic lens for research in education. *Review of Research in Education,* 25:99–125.

Grote, M.G. 1995. Teacher opinions concerning science projects and science fairs. *Ohio Journal of Science,* 4:274–277.

Gruenewald, D.A. 2003a. The best of both worlds: A critical pedagogy of place. *Educational Researcher,* 32(4):3–12.

Gruenewald, D.A. 2003b. Foundations of place: A multidisciplinary framework for place-conscious education. *American Educational Research Journal,* 40(3):619–654.

Hill, A., Hirshberg, D., Lo, D.E., McLain, E.A., and Morrotti, A. 2013. Alaska's university for Alaska's schools 2013. Anchorage, AK: Center for Alaska Education Policy Research, University of Alaska. Available at http://www.alaska.edu/files/shapingalaskasfuture/SB2412012-2013-.pdf (accessed 17 February 2014).

Huntington, H.P. 2000. Using traditional ecological knowledge in science: Methods and applications. *Ecological Applications,* 10(5):1270–1274.

Hurtado, S., Cabrera, N.L., Lin, M.H., Arellano, L., and Espinosa, L.L. 2008. Diversifying science: Underrepresented student experiences in structured research programs. *Research in Higher Education,* 50(2):189–214.

International Program on Traditional Ecological Knowledge. 1993. Traditional ecological knowledge: Concepts and cases. Ottawa, Canada: International Program on Traditional Ecological Knowledge.

Kawagley, A.O. 1993. A Yupiaq world view: Implications for cultural, educational, and technological adaptation in a contemporary world [Ph.D. thesis]. Vancouver, Canada: University of British Columbia. Available from https://circle.ubc.ca/handle/2429/2016 (accessed 17 February 2014).

Kawagley, A.O. 1995. A Yupiaq worldview: A pathway to ecology and spirit. Prospect Heights, IL: Waveland Press.

Kawagley, A.O., and Barnhardt, R. 1998. Education indigenous to place: Western science meets native reality. Available at http://www.ankn.uaf.edu/curriculum/Articles/BarnhardtKawagley/EIP.html (accessed 17 February 2014).

Kawagley, A.O., Norris-Tull, D., and Norris-Tull, R.A. 1998. The indigenous worldview of Yupiaq culture: Its scientific nature and relevance to the practice and teaching of science. *Journal of Research in Science Teaching,* 35(2):133–144.

Kozoll, R.H., and Osborne, M.D. 2004. Finding meaning in science: Lifeworld, identity, and self. *Science Education,* 88(2):157–181.

Kozoll, R.H., and Osborne, M.D. 2006. Developing a deeper involvement with science: Keith's story. *Cultural Studies of Science Education,* 1(1):161–187.

Kuwahara, J.L. 2013. Impacts of a place-based science curriculum on student place attachment in Hawaiian and Western cultural institutions at an urban high school in Hawaii. *International Journal of Science and Mathematics Education,* 11(1):191–212.

Lawton, C.A., and Bordens, K.S. 1995. Gender differences in science interests: An analysis of science fair projects. Paper presented at the 61st Biennial Meeting of the Society for Research in Child Development. Indianapolis, IN: Institute of Educational Resources.

Lemke, J.L. 2001. Articulating communities, sociocultural perspectives on science education. *Journal of Research in Science Teaching,* 38(3):296–316.

Michell, H., Vizina, Y., Augustus, C., and Sawyer, J. 2008. Learning indigenous science from place. Saskatoon, Canada: Aboriginal Education Research Centre.

National Education Association. 2011. Rankings and estimates: Rankings of the states 2011 and estimates of school statistics 2012. Washington, DC: NEA.

National Research Council. 2012. A framework for K–12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: Committee on a Conceptual Framework for New K–12 Science Education Standards, Board on Science Education, National Academy Press.

Oakes, J.E., and Riewe, R.R., eds. 2006. Climate change: Linking traditional and scientific knowledge. Winnipeg, Canada: Aboriginal Issues Press.

Riedlinger, D., and Berkes, F. 2001. Contributions of traditional knowledge to understanding climate change in the Canadian arctic. *Polar Record,* 37(203):315–328.

Roth, E.J., and Li, E. 2005. Mapping the boundaries of science identity in ISME's first year. Montreal, Canada: American Educational Research Association.

Schneider, R.M., and Lumpe, A.T. 1996. The nature of student science projects in comparison to educational goals for science. *The Ohio Journal of Science,* 96(5):81–88.

Semken, S. 2005. Sense of place and place-based introductory geoscience teaching for American Indian and Alaska Native undergraduates. *Journal of Geoscience Education,* 53(2):149–157.

Snively, G., and Corsiglia, J. 2001. Discovering indigenous science: Implications for science education. *Science Education,* 85(1):6–34.

Sonnert, G., Sadler, P., and Michaels, M. 2013. Gender aspects of participation, support, and success in a state science fair. *School Science and Mathematics,* 113(3):135–143.

Stephens, S. 2001. Handbook for culturally-responsive science curriculum. Fairbanks, AK: Alaska Science Consortium and Alaska Rural Systemic Initiative.

Stets, J.E., and Burke, P.J. 2000. Identity theory and social identity theory. *Social Psychology Quarterly,* 63(3):224–237.

Tremblay, M., Furgal, C., Lafortune, V., Larriv, C., Savard, J., Barrett, M., and Etidloie, B. 2006. Communities and ice:

Bringing together traditional and scientific knowledge. *In* Riewe, R., and Oakes, J., eds., Climate change: Linking traditional and scientific knowledge. Winnipeg, Canada: Aboriginal Issues Press, p. 285.

Tsurusaki, B.K., Calabrese-Barton, A., Tan, E., Koch, P., and Contento, I. 2013. Using transformative boundary objects to create critical engagement in science: A case study. *Science Education,* 97(1):1–31.

Twigger-Ross, C.L., and Uzzell, D.L. 1996. Place and identity processes. *Journal of Environmental Psychology,* 16(3):205–220.

Tzou, C., Scalone, G., and Bell, P. 2010. The role of environmental narratives and social positioning in how place gets constructed for and by youth. *Equity and Excellence in Education,* 43(1):105–119.

Varelas, M., Martin, D.B., and Kane, J.M. 2012. Content learning and identity construction: A framework to strengthen African American students' mathematics and science learning in urban elementary schools. *Human Development,* 55:319–339.

Williams, M.M., and George-Jackson, C.E. 2011. Considering the role of gender in students' science identity. Manuscript of paper presented at the 2011 American Education and Research Association Annual Meeting. Available at http://stepup.education.illinois.edu/papers (accessed 17 February 2014).

Yasar, S., and Baker, D. 2003. The impact of involvement in a science fair on seventh grade students. *In* Proceedings of the 2002 Annual Meeting. Philadelphia: National Association for Research in Science Teaching, p. 1–12.

APPENDIX

The Big Empty was a research project conducted in 2010 by Ember Eck and China Kantner, two Kotzebue High School students in the Iñupiaq region of Alaska. Their award-winning poster exemplified the goals of the COSEE-AK Ocean Science Fair concept of aligning local and traditional knowledge with the practices of Western science.

The Big Empty science project demonstrated evidence of changes in northern Alaska due to climate change. The focus was Silver Dollar Lake in the Kobuk Valley National Park, where the Eck family stayed every summer. Family members and community Elders had observed that the lake was changing physically. Changes to the lake were also culturally significant, because it is a stopover site for migratory waterfowl. Loss of habitat at this and nearby lakes would mean the bird populations are likely to decline, impacting subsistence-based cultural practices.

Eck and Kantner first interviewed an Iñupiaq Elder to learn about historic observations and find out about changes witnessed by community members. Following interviews with the Elder, and with the support of researchers Amy Larson, an aquatic ecologist with the National Park Service, and Cynthia Dinwiddie, a hydrologist and engineer with the Southwest Research Institute, the students framed a hypothesis about the changing lake conditions. They established research procedures and set about their inquiry.

Their research on Silver Dollar Lake required access to historic and recent aerial and satellite photographs. Eck and Kantner developed a method to measure and plot the area of the lake on graph paper. Because the photographs were of different scales, the students were required to calculate surface area changes among images, as well as changes over time. In their ocean science fair poster, these student scientists presented data demonstrating a 51% loss of surface area of the lake between 1952 and 2010, with 31% of that loss happening in the last 3 y. Photos, graphs, and computations were included on their poster as evidence of the reduction in lake surface area.

Eck and Kantner learned that Silver Dollar Lake is a thermokarst lake that formed as the surface layer of permafrost melted each summer. But in contrast to most thermokarst lakes on the North Slope of Alaska, which have increased in size in recent years, Silver Dollar Lake was decreasing. Understanding why required additional research. Their continuing inquiry led to further conversations with scientists. The students discovered that there could be several explanations, including changes in precipitation or changes in spring thaws. For Eck and Kantner, the most compelling explanation was that the rate at which the permafrost melted may have increased to the point where the underlying frozen layer that provided a barrier to soil drainage during the summer had disappeared so that the water was simply draining each summer. An additional concern for the two students was the potential increase in methane and carbon dioxide release into the atmosphere, thereby increasing the speed of the melting process through the increase in greenhouse gasses.

The Big Empty project received a first place award at the district level of the regional science fair. At the Alaska Science and Engineering Fair in 2011, the poster was judged for both scientific and cultural merit. The poster won first place in the combined category. Following the statewide fair award, COSEE-AK sponsored the students to attend the 2012 Alaska Marine Science Symposium in Anchorage, where the two students presented a poster, talked about their research with ocean scientists from around the world, and received an award for the best poster by a high school or undergraduate student.

The experience of seeing problems through the lens of the local community and addressing issues with scientific methods was transformative for these two students. Through their research they met and were mentored by research scientists they would otherwise not have met. They acknowledge that they acquired new skills including interviewing, conducting research, drawing conclusions, representing their results graphically and in narrative, and learning to speak with confidence to audiences that included professional scientists. Both students continue their deep engagement in science and intend to continue with science.