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Iḷisaġvik Tribal College's summer climate program: teaching STEM concepts to North Slope Alaska high school and middle-school students

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Abstract The incorporation of informal science modules with traditional ecological knowledge (TEK) engages students in Science, Technology, Engineering, and Mathematics (STEM) courses. During the summers 2012–2015, Iḷisaġvik Tribal College, located in Barrow, AK, hosted an average of 12 rural Alaska Native middle-school and high school students per year in the college's summer STEM program called "Climate and Permafrost Changes on the North Slope: In Cultural Context." Teaching the carbon cycle as a core concept, this 2-week STEM program examined climate change and its effects on the local landscape from a multitude of perspectives. Elders shared their observations and experiences associated with climate change. Local and visiting scientists gave presentations and taught through games, hands-on laboratory simulations, and practical field work—all relevant to the camp's science content. Pre-assessments and post-assessments using the Student Assessment of Learning Gains measured student interests and conceptual understanding. Students developed and enhanced their understanding of science concepts and, at the end of the camp, could articulate the impact of climactic changes on their local environment.

Keywords STEM · Informal science · Climate change · Traditional ecological knowledge

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Introduction

Located 300 mi north of the Arctic Circle, the North Slope Borough is home to approximately 10,000 people residing in eight villages (Fig. 1). The majority of the residents are Iñupiat Eskimo (>75 %) whose rich cultural heritage exceeds 10,000 years (Shepro 2010). According to the official website of the North Slope Borough (NSB 2016), "Today, Iñupiat still look to the land for cultural and economic sustenance." While the Iñupiat have embraced economic and technological changes, they additionally depend on whaling, hunting, and fishing for cultural identity and much of their food supply. These practical skills and values or traditional ecological knowledge (TEK) are passed from Elders to youth, providing a dynamic cultural connection that uses observational methods and storytelling to examine environmental change. Global warming, a growing community concern, for example, may have significant impacts on the local environment and waters. Changes in ice are already occurring with the high rate of sea-ice decline leading to unstable ice conditions, which could create tremendous dangers during the winter hunting season for seals, walrus, and whales. Erosion, thawing permafrost, and changes in plant and animal migration are also affected by a warming climate.

Over the last 60 years, Alaska has experienced a 6 °F increase in winter temperatures and a 3 °F increase overall, twice that of the rest of the planet (EPA 2015). On the North

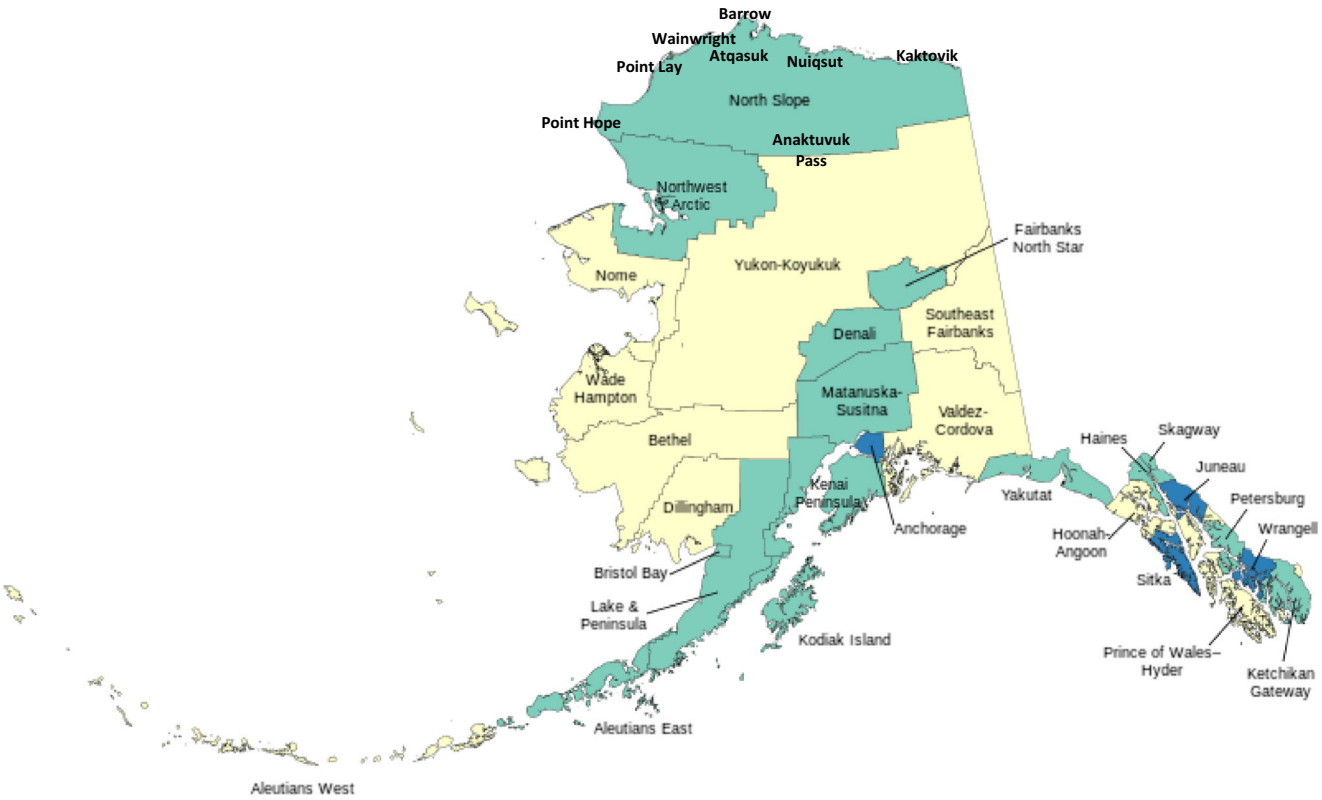

Fig. 1 Map of the North Slope Borough (NSB) used with permission from the NSB Department of Planning/GIS Division (source, http://www.north-slope.org/assets/images/uploads/NSBCensus2010.pdf.). Barrow, AK, is the most populated village averaging around 4500 people, 61 % being Alaska Native. The remaining village (Anaktuvuk Pass, Atqasuk, Kaktovik, Nuiqsut, Point Hope, Point Lay, and Wainwright) populations range from 900 to 200 people, 90–95 % being Alaska Native

Slope, the resultant ecological changes have been both positive and negative. Personal witnesses to global warming, North Slope youth are observing significant changes to the landscape. Although local and national leaders are addressing climactic concerns and adaptation and resilience protocols are being formed, it is imperative that North Slope youth are informed as well. Knowledge of current climate science theory and practice can give students the confidence needed to become active members and voices within their communities when strategic choices to mitigate climate change impacts are required (Perkins et al. 2014). Alaska Native youth often are confronted with straddling the fence in a world of technological advances and traditional knowledge. This program is designed to enhance student learning by blending lessons of Western science and discussions with Elders on TEK on environmental issues associated with climate change. Self-assessment is utilized to help determine if students have an increase of knowledge at the end of the program.

Up to the early 1900s, Native knowledge and Western science were classified as two mutually independent systems (Barnhardt 2005; Stephens 2000). By the nineteenth century, an extensive amount of literature compared these two systems. While Western science is transmitted through academics and literature, on the contrary, traditional knowledge is transmitted through generations of oral story telling by Elders (Fulvio Mazzocchi 2006; Medin and Bang 2014). Isolation of the objects of study, or separation from nature, is common in Western science, while traditional knowledge consistently depends on its environment and its distinct conditions (Nakashima and Roué 2002). As pointed out by Greg Lowan (2012), tensions between Western and Indigenous science have led to scholars such as Gregory Cajete, Ray Barnhardt, and Angayuqaq Oscar Kawagley to seek a common ground, "an existential and epistemological meeting place" between traditional Native knowledge and Western science (Fig. 2). Today, relationships between local and visiting educators, scientists, community scholars, and Elders can facilitate closing the TEK and Western science gap.

Climate and Permafrost Changes on the North Slope: In Cultural Context program was developed through a partnership with Iḷisaġvik Tribal College, the University of Alaska Fairbanks, and supporting collaborators. This program is a short two-credit course but runs in an interactive manner. Student selection was primarily based on students' interest in science, but anyone was eligible to apply. For example, one student's main interest was in culinary arts, but she indicated that she was very concerned about the environmental changes occurring in her village due to climate changes. Her village, Shishmaref, is facing

Fig. 2 From the Handbook for culturally responsive science curriculum (Stephens 2000)

grave coastal erosion that could lead to the necessity to evacuate the entire community. As we were only looking for an increase in knowledge, GPA was not a factor in the selection of students. With Barrow being the largest community with the most student applicants, we did assure that our selection of students was from several different rural villages to include one or two outside of the North Slope Borough.

The course curriculum consists of modules that address Arctic ecology, the carbon cycle, natural resources, global warming, and the physical impacts of a warming climate (Fig. 3). Modules are a practical means of presenting scientific content to varying age groups equivalent to grades 7–12 (Nicholas-Figueroa, et al. 2015). Informal science, with a strong layer of TEK, encourages student engagement; the modules reflect the students' rural upbringing and their interaction and expertise with technology (Duffy, et al. 2011a; Nicholas-Figueroa, et al. 2015). Lessons, such as the physical impacts of a warming climate, included a scientific presentation, lab activities and/or field trips, and discussions with Elders leading to dynamic interactions between the students, scientists, and Elders.

Methods

Student assignments

Students attending the camp were given out-of-class assignments, maintained a daily journal, wrote a minimum 500-word essay, and delivered a presentation at the end of the camp. Assignments were based on the materials that covered

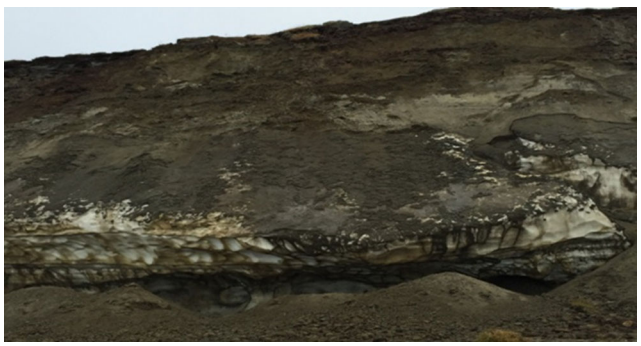

Fig. 3 Coastal erosion, Barrow, AK. Photograph by Linda Nicholas-Figueroa

the periodic table, elements, carbon, combustion, greenhouse gases, and climate change. The students were required to take daily notes in their journals on the scientific lectures, hands-on/lab activities, Elder discussions, and field trips. The journals were collected and returned with informational comments that supplemented their notes, enhancing the learning process. Students were encouraged to write their essays on topics of interest to them. The students prepared a public presentation integrating the knowledge gained from the assignments, scientists, Elders, and fieldtrips.

Meetings with scientists

Local and visiting scientists presented information to the students through presentations, hands-on activities, laboratory simulations, and games. Foundational topics such as carbon chemistry, weather and climate, greenhouse gases, atmospheric CO_2, and global warming were presented by instructional faculty: Linda Nicholas-Figueroa, Iḷisaġvik College; Drs. Rebekah Hare and Lawrence Duffy, University of Alaska Fairbanks; Dr. Cathy Middlecamp, University of Wisconsin-Madison; and Dr. Bob Rabin, NOAA/National Severe Storms Laboratory. Visiting presenters provided a breadth of topics emphasizing the impacts and issues associated with a changing Arctic (Table 1).

Meetings with Iñupiat Elders

Exposure to traditional knowledge occurred through lessons with local Elders. Information gained from this experience will help the students to develop and enhance their personal understanding of the significant relationship and impact of climate change on their local villages/communities. These were two-way discussions between the Elders and students. There was no set format for the discussions allowing the Elders to speak freely and adapt the conversations to student inquiries (Table 2).

Field trips

An integral camp component, field trips demonstrated practical applications of conceptual topics covered by both the scientists and Elders. Students were exposed to real-time activities that correlated with lessons learned and proved concrete examples of Science, Technology, Engineering, and Mathematics (STEM) concepts learned in class. These outings additionally demonstrated the scientific importance of the North Slope Borough to scientific inquiry. Table 3 lists the sites visited, the role played in the Arctic and/or local community, and any activities that the students observed/performed during their visit.

Assessment

The Student Assessment and Learning Gains (SALG) (Seymour et al. 2000; SALG 2013), a student survey instrument developed by the Science Education for New Civic Engagements and Responsibilities (SENCER) project, was used both at the beginning and end of the camp. SENCER is a national STEM curriculum reform project initiated in 2000 with funding from the National Science Foundation. Students took a SALG pretest survey at the beginning of the camp and

Table 1 Student interaction with visiting and local scientists

Scientist	Affiliation	Presentation topic
Dr. Christian Andersen	University of Texas at El Paso	Local lakes: understanding of long-term changes in biological, hydrological, and chemical systems due to climate change.
Dr. Robert Hollister	Grand Valley State University	Vegetation: the importance of global warming and the response of changing tundra.
Dr. Jenny Cunningham	University of Missouri	Shoreline birds: change in migration patterns with warming climate.
Dr. Debendra Das	University of Alaska Fairbanks	Permafrost: the effects of thawing permafrost on infrastructure.
Dr. Craig George	Department of Wildlife Management, Barrow AK	Bowhead whales: early plankton bloom may change feeding patterns.
Dr. Robert Sudyam	Department of Wildlife Management, Barrow AK	Beluga whales: offshore drilling can change migratory patterns.
Dr. Justin Bagley	University of Illinois	Land cover change/global food production and climate change: how will food and energy crops meet global demands, and how those demands will impact the environment.
Dr. Eric Wilkman Dr. Katherine McEwing	University of California San Diego University of Sheffield, UK	Biogeochemical cycles: climate change and the role of greenhouse gases in the atmosphere and the carbon cycle and the roles of plants and microbes.
Dr. Chris Cuomo Dr. Wendy Eisner	University of Georgia University of Cincinnati	Permafrost and thawing lakes as witnessed by Elders, hunters, and berry pickers.

Table 2 Student interaction with North Slope Borough Elders

Elder	Affiliation	Presentation topic
Mr. James Nageak	Iñupiat History, Language and Culture Commission and Iḷisaġvik College Board of Trustees	The dilemma of roads: there is a proposal to build a road to Anaktuvuk Pass. This could be a positive economic impact as foods and other goods would not have to be flown in versus the potential impacts of loss of wildlife and cultural integrity.
Ms. Ida Olemaun	Arctic Slope Regional Cooperation Board of Directors	Tourism and culture: with the Northwest Passage opening up, tourism is on the rise. This can be economically beneficial, but such things like cruise ships can cause concerns for the ecological environment and culture.
Mr. Nate Olemaun	Whaling Captain	Sea ice loss: storms are becoming more frequent due to the loss of sea ice, which leads to beach and land erosion.
Ms. Martha Stackhouse	Iḷisaġvik College Coordinator for Teachers of the Arctic	North Slope plants: invasive plant species are moving North bringing in more berries, but some new tall grasses might be harmful for the native plant species
Mr. Robert Suvlu	Uquautchim Uglua (Early Childhood Learning) Iñupiaq Culture-Based Coordinator at Iḷisaġvik College	Traditional knowledge: importance of learning how to read and respect the environment and paying close attention to the rapid environmental changes are crucial for adaptation.
Mr. Eugene Brower	Arctic Slope Regional Corporation Board of Trustees and President of Barrow Whaling Captains Association	Thinning sea ice and ice-cellars: dangerous conditions during spring whaling, which occurs on the edge of the ice. Most hunted meats (whale, caribou, seal, and walrus) are stored in ice cellars. Foods stored in ice cellars are spoiling due to melting permafrost.

Table 3 Program field trips

Agency visited	Agency role	Field trip activities
The National Oceanography and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) Global Monitoring Division (GMD)	The GMD monitors atmospheric gases such as carbon dioxide, methane, other trace elements, and aerosols that can alter the Earth's climate. This research provides information for climate projections and scientific support for societies to make informed decisions (NOAA, ESRL, GMD 2015).	Students set up an air flask sample and completed a pump sample. They completed systems' check sheets that familiarized them with the instrumentation and the technician's job requirements; they heard cloud formation and ozone layer presentations, completed observations of the ozone layer, and watched a video detailing greenhouse gasses.
The Department of Energy/Atmospheric Radiation Monitoring (ARM)	The ARM Climate Research Facility collects data from a variety of sources and scientists use these data to research and monitor atmospheric radiation and cloud coverage, each having an impact on global climate change (Department of Energy 2015).	Students observed instrumentation such as the Sky Radiation radiometer, which provides information about the solar, infrared, and ultraviolet radioactive energy exchange on the North Slope of Alaska.
The NOAA National Weather Service (NWS) Alaska Region	The NWS covers the state of Alaska and its surrounding waters. The information collected includes hydrology, volcanic ash, tsunamis, daily and long-term weather patterns, and climate predictions. The Barrow NWS launches a weather balloon with attached weather instruments twice daily. The collections of weather trends are becoming increasingly more sensitive (NOAA, NWS 2015).	Students launched the weather balloon. They also watched scientists demonstrate how they take, record, augment, and disseminate aviation observations (METAR) using the Automated Surface Observing System (ASOS). They also discussed sea ice observations and upper-air rawinsonde (weather instruments sent aloft by weather balloons) observations, and how all of these observations are tied together to produce local and short-range and long-range weather forecasts. The information gained through these observations is used in climatological studies.
Barrow Utilities Electric Co. Inc. (BUECI)	The BUECI operates seven generators providing Barrow with natural gas, electricity, and water. Running water is transported through permafrost in the Barrow Utilidor System, a 3.2-mi underground wooden structure. (BUECI 2015)	Students toured BUECI facilities, including the Utilidor, learning about water treatment and electrical generators. Students could see first-hand the carbon fuels burned to produce energy and transport water for the Barrow community.
Sea Ice Radar Station	The Sea Ice Radar Station, with offices in Barrow and Wales, AK, observes coastal ice movement. The Barrow site also maintains a station to determine sea ice mass balance and sea-level rise. This station also produces forecasts for the early summer breakup of landfast ice (Sea Ice Group 2015).	Imaging and animations are produced using data from a 25-kW X-band marine radar mounted atop the four-story bank building in downtown Barrow. Images are archived about every 5 min to monitor processes that shape the landfast ice and can last only a few hours. Sea ice can be detected at ranges of up to about 10 km (6 mi). Radar signals are reflected by rough ice, which appears as bright areas in these images. Sea ice ridges appear as lines of bright reflections.

repeated it as a post-test. The analysis focused on student self-assessment of understanding of how topics relate to (1) greenhouse gases and the carbon cycle, (2) burning of fossil fuels, (3) their village, and (4) other real-world issues. The six unit Likert scale response options to a statement were 1: not applicable; 2: not at all; 3: just a little; 4: somewhat; 5: a lot; and 6: a great deal. Using the SENCER rubric is like performing a mental audit; each student makes a qualitative assessment of their knowledge or understanding of the issue. The instructional faculty can view the summation of the student gains as follows: not observed (scale values 1 or 2), basic (scale values 3 or 4), a lot (advanced, scale value 5, greater presence of knowledge), and a great deal (transformative, scale value 6, sees relationships). The SALG instrument does not identify individual students and automatically calculates means and standard deviations and generates graphs of the data (Duffy et al. 2011b).

Conference attendance

Many rural Alaska Native villages are only accessible by airplane rendering travel difficult and expensive. However, it is important for rural Alaska Native students to travel and be exposed to scientific or other academic conferences. Conference attendance is a positive way to enhance and reinforce the students' learning gains as they interact with scientists and other students from many different geographical regions. Two conferences were selected for the students to attend: the 18th Inuit Studies Conference and the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science National Conference. Both conferences offer students the opportunities to gain soft skills such as learning how to communicate scientific data.

Results

Using the SALG assessment tool, students reported how class activities such as lectures, discussions with Elders, and field trips helped their comprehension of the topics discussed (Table 4). Students report a general increase in learning about all topics with the exception of "what global warming is."

Students reported the significant learning gains for "the burning of methane" ($p \leq 0.01$) and "what are biogeochemical cycles" ($p \leq 0.002$). Figures 4 and 5 illustrate the gain in knowledge for the understanding of "what greenhouse gases are" ($p \leq 0.01$) and "how these topics can relate to my village" ($p \leq 0.009$).

Using assignments, journal entries, and an essay, the students created presentations delivered to Iḷisaġvik College staff and community members. Each student selected an issue of personal interest and learned presentation organizational and public speaking skills. Students were evaluated in these areas; however, the majority of the grade was based on knowledge of content. Table 5 lists the titles of the student presentations.

Discussion

Understanding the carbon cycle and its impact on climate change was the recurrent theme of the 2-week program. Instructors Middlecamp, Duffy, Nicholas-Figueroa, and Hare introduced the concept of the carbon cycle and spent 2 days reinforcing the concept through a variety of activities. The message was threefold: (1) carbon is found in many places, (2) carbon moves from place to place, and (3) where it ends up matters. The fact that carbon dioxide is a colorless, odorless gas and essentially "invisible" makes the communication of this message, in a manner that maintains student attention, a significant challenge. Students cannot "see" carbon in grazing

Table 4 Mean and standard deviation values of questions answered by students prior to the beginning of camp and answers to the same questions at the end of camp

Topic Presently I understand…	Mean pretest	STD pretest	Mean post-test	STD post-test
How elements are organized on the periodic table	3.9	0.83	4.1	1.25
The burning of methane*	3.2	1.67	4.8	1.04
What greenhouse gases are*	4.6	1.41	5.8	0.46
The differences between weather and climate	4.9	1.13	5.6	0.74
What global warming is	5.2	0.89	5.2	1.16
Why air is monitored	4.2	1.75	4.5	1.31
The importance of permafrost	5.1	0.83	5.5	0.76
What biogeochemical cycles are*	2.2	1.04	3.8	0.89
How topics covered can relate to my village*	4.5	0.93	5.6	0.74
How studying the subject helps people address real-world issues	4.8	1.04	4.9	1.13

*Significant at $p < .05$

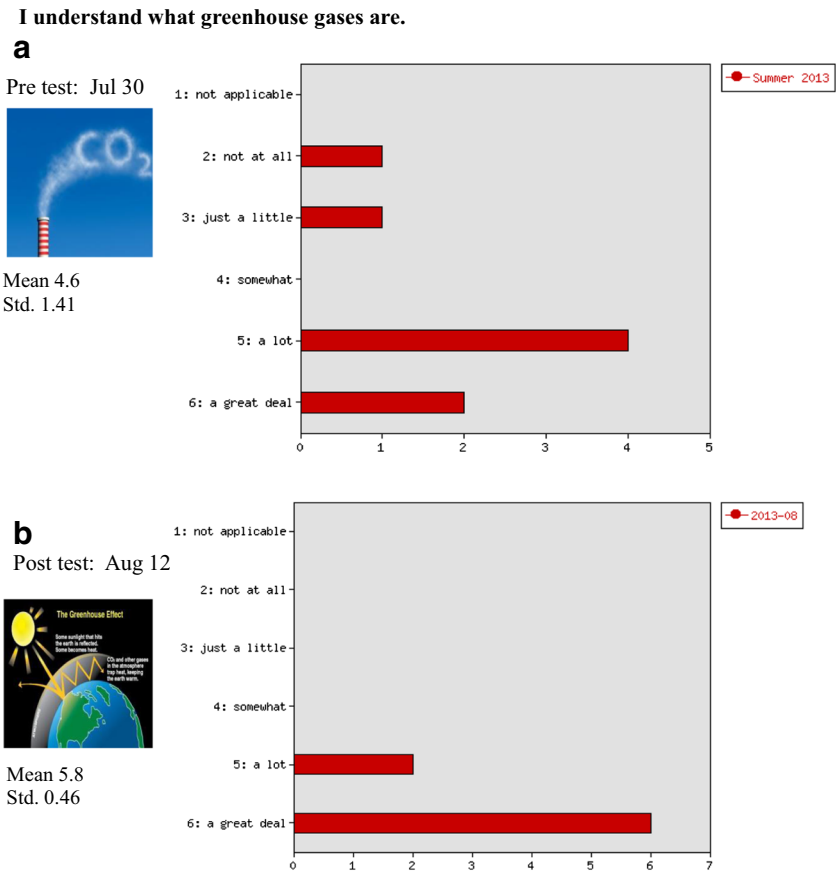

Fig. 4 Student Assessment and Learning Gains (SALG) results for the question "I understand what greenhouse gases are." Pretest and post-test means were significantly different, $p \leq .01$

caribou, their breakfast cereal, or a graphite pencil, all seemingly unrelated objects. Compounding the issue further is the fact that carbon is found in many chemical forms ranging from methane to crude oil to whale blubber. Students are unable to detect many forms of carbon with their own senses or easily see the impact of these forms on the environment (Fig. 6).

Instructors carefully assessed students' baseline carbon knowledge and then proceeded to advance it. Interactive activities such as the carbon cycle game included student role playing carbon in different reservoirs (sinks): fossil fuels, atmosphere, or the ocean. A field trip to the Barrow Utilities and Electric Company provided a first-hand look at the carbon-based fuels that are burned to produce energy and transport water for the Barrow community.

Capitalizing on the wealth of Barrow's local and visiting scientific knowledge, the instructors invited scientists who spoke about climate change issues that reinforced the fundamental relationship of the carbon cycle to a changing climate. Students learned about changes occurring in weather patterns and their effect on the environment, the arctic wetlands and the millions of migratory birds that visit each summer, human and ecosystem interaction specifically on the tundra, how greenhouse gasses are impacting the environment, and the changing permafrost. During fieldtrips, students were exposed to a wide variety of instrumentation, covering remote sensing satellites, time lapse photography, and dynamic soil flux chambers to name only a few (Table 6).

Of equal importance was the opportunity to spend time with North Slope Elders who spoke of topics related to climate change: economics, storms, sea ice, polar bears, walrus, whales, caribou, ice cellars, invasive species, traditional knowledge and science, and adaptation and policy. For example, Elder Martha Stackhouse spoke about changing plant and animal migration patterns as the climate warms and invasive species are migrating north.

> There are more sourdocks than ever, and the pussy willows are taller than they have ever been. Grass niches used to only be inches in diameters are now several feet in diameter. There are many new plants in Barrow; Fireweed now grows in Barrow, when it once did not. Cranberries and Labrador tea are coming further north. The berries (salmonberries and cranberries) are almost to Wainwright. (Martha Stackhouse, personal communication, July 2015.)

Students were thoroughly engaged during the Elders' visits. They listened intently and asked questions. Students learned from the Elders who shared their own personal experiences through stories while, at the same time, pass on traditional knowledge. As climate is warming fastest in the Arctic,

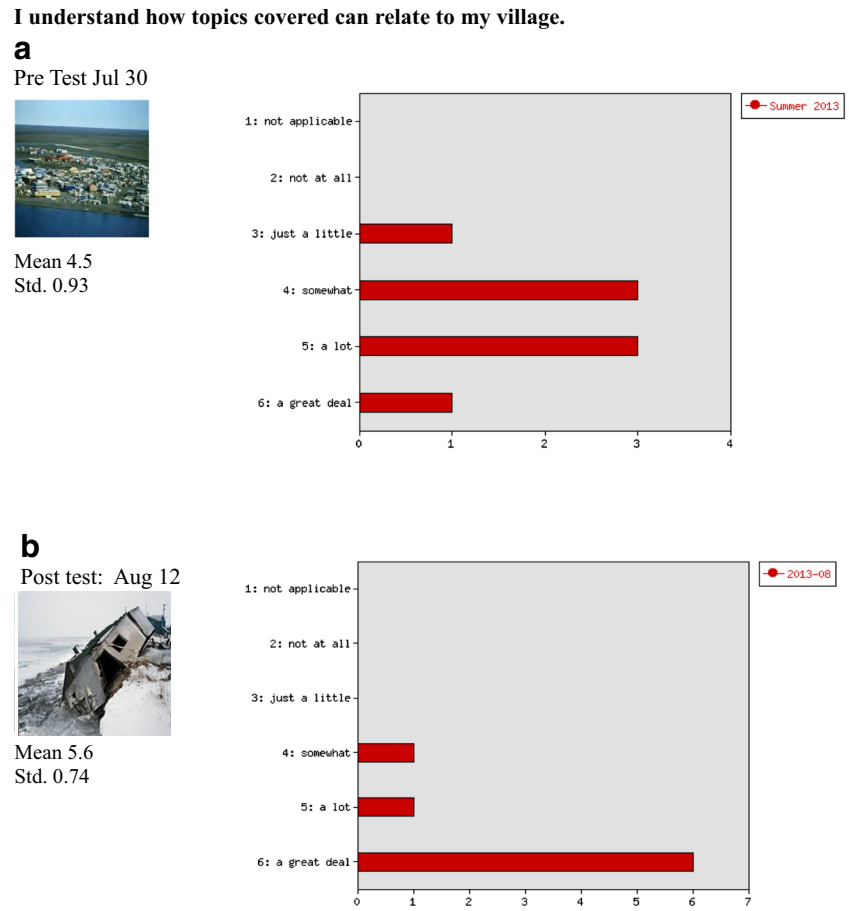

Fig. 5 Student Assessment and Learning Gains (SALG) results for the question "I understand how topics covered can relate to my village." Pretest and post-test means were significantly different, $p \leq .009$

the students often have stories to tell from their own observations.

High school students, especially those from rural areas, rarely have the opportunity to interact with the scientific community. The course design planned on students obtaining information that would lead them to attend a scientific meeting. Three students (two from Wainwright, AK, and one from Shishmaref, AK) attended the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS) National Conference, where they attended symposiums, leadership development seminars, poster (Fig. 7), and keynote sessions. Two Barrow students and one student from Point Lay were selected to attend the 18th Inuit Studies

Table 5 Student presentation titles

Carbon dioxide
Climate change affecting caribou
Climate change affecting geese
Climate change on the sea ice
Climate change: melting permafrost is affecting our ice cellars
Global warming in Alaska: sea ice
Global warming solutions
How climate change affects whales
Permafrost and greenhouse gases
Temperature effects
The difference between weather and climate change
The effects of climate change on land and infrastructure

Kate Cooper, Institute for Computing in Humanities, Arts and Social Science, assisted students with their public presentation preparations

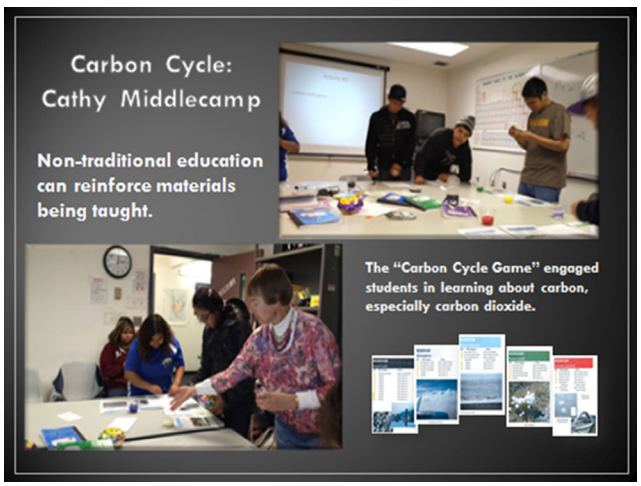

Fig. 6 Students learned about carbon and then played the *Carbon Cycle Game* reinforcing carbon's movement from air to land to water to plants and animals. Photograph by Linda Nicholas-Figueroa

Table 6 North Slope fieldtrip presentations

Scientist	Affiliation	Presentation details
Dr. Bob Rabin	NOAA, National Severe Storms Laboratory	Computer-based activities gave students an opportunity to learn about remote observation, such as satellites, and how they are used in climate research and weather forecasting. Dr. Rabin explained satellite observations of clouds, sea, ice, and land. Students used geostationary satellite and NASA's high-resolution imagery for real-time weather observations. Students watched annual ice movement from scatterometers (space radar), analyzed snow and ice cover change, interpreted weather forecast models, and made their own weather forecasts. The film, *Inuit Observations on Climate Change*, was shown.
Dr. Christian Andersen	University of Texas at El Paso	Dr. Andersen uses a combination of aquatic ecology and remote sensing to understand long-term changes (biological, hydrological, chemical) in the arctic wetlands. The use of a kite rig and time-lapse photography for monitoring was demonstrated.
Dr. Robert Hollister	Grand Valley State University	Interested in the interactions between humans and natural ecosystems with an emphasis in vegetation change, Dr. Hollister discussed the response of changing tundra to global warming. Dr. Hollister discussed his findings on how climate change is affecting tundra ecosystem land use.
Drs. Eric Wilkman and Katherine McEwing	University of California San Diego University of Sheffield, UK	Drs. Wilkman and McEwing reinforced the importance of understanding the carbon cycle. They provided a context for the roles played by greenhouse gasses, permafrost, and microbes and plants in the large-scale process and explained how changes in the Arctic affected the global carbon cycle and impacted climate change. They included explanations of methodology and instrumentation that measure trace gas fluxes. Wilkman and McEwing invited the students to the Barrow Environmental Observatory and showed them the instrumentation (eddy covariance towers, dynamic soil flux chambers) in action.

Conference in Washington, DC, where they delivered their community presentations on climate change and participated on a youth discussion panel.

Elise Patkotak, reporting for the *Arctic Sounder*, wrote

> Student participant Kenneth Ivanoff told Nicholas-Figueroa, who accompanied the students to Washington, that he was excited about meeting so many people from so many different places in the world. He told her he learned a lot from the sessions he attended and, in particular, enjoyed the plenary speech by Mark Serreze, Director of the National Snow and Ice Date Center. According to Ivanoff, Serreze "talked about things I learned in summer camp about the effects of global warming on sea ice and permafrost in the Arctic." Mead Treadwell, Alaska's Lt. Gov., also spoke and discussed "the State's work addressing cultural challenges, resource development, and environmental change." As liaison for Alaska to the Arctic Council, he addressed the issues of international geopolitics as it related to the work of the Arctic Council (Patkotak 2013).

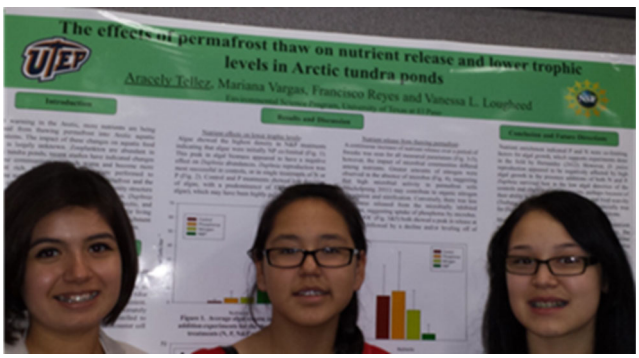

Fig. 7 Students attending SACNAS poster session. Photograph by Linda Nicholas-Figueroa

Future efforts

Future effort will be devoted to the development of similar modules focused on TEK and STEM topics associated with community workforce development goals. Iḷisaġvik College offers STEM science camps for youth on the North Slope to introduce them to research being conducted in their immediate environment. Science curricula in the form of short courses such as a biotechnological skills workshop and citizen science projects with the North Slope Borough School District are being

developed. Next steps include partnership with UMIAQ Science, a subsidiary of the Ukpeaġvik Iñupiat Corporation, to create internships for college and high school students to work with local and visiting scientists in Barrow. Climate change is a complex system involving both ecosystem services and human social and political systems. Both the social issues and the science can be used to engage students (Duffy et al. 2011a).

Our goal is to engage students so that they can see STEM's abstract (invisible) concepts in their lives and communities. It is practical to combine the traditional, holistic world view of the community with the reductionist scientific approach. The community's perspective is that "Western science" has much to learn from traditional ecological knowledge (TEK) and its associated values of living on the land. In order to maintain a dynamic culture, it is essential that TEK be a strong component of their children's education for their long-term well-being.

Conclusion

This summer STEM program is an informal way of engaging students in science concepts while seeing the relevance to real-world issues. Student assessment showed an increase in knowledge to how real-world issues can directly relate to community concerns, such as the local challenges of adapting to a changing climate. By connecting the science to the region, cultural traditions and values are inserted into the learning experience. This interdisciplinary approach makes the science, as well as the social, economic, and cultural relationships, visible. Teaching science in a holistic, informal context with both Western and TEK provides a balanced perspective as we educate tomorrow's leaders and decision makers.

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