Creating Pathways Toward Geoscience Education for Native American Youth: The Importance of Cultural Relevance and Self-Concept

Sara Unsworth,[1,a] Eric M. Riggs,[2] and Marc Chavez[3]

ABSTRACT

Native American nations in the United States have a unique legal status that is rooted in a complex relationship between the United States federal government, individual state and local governments and tribal authorities. Although geosciences are often at the center of these relationships, especially as they pertain to the development of natural resources, tribal economics, and environmental stewardship, Native Americans remain severely underrepresented in advanced geoscience education. We evaluated the effectiveness of a culturally grounded, field-based geoscience education program for Native American adolescents using pre- and postprogram surveys. The results showed that at the end of the program, youth were more likely to agree that their tribe uses science to manage natural resources, their tribe has always used science, and earth and rocks make them who they are. These responses were related to an increased likelihood to agree that what can be learned in school is important to their tribe, that they will go to university, and that they could be scientists as adults. These findings highlight the importance of two factors in helping to create pathways toward the geosciences for Native youth: 1) perceived relevance of science to tribes, and 2) self-concepts (e.g., concepts of self as earth, rocks, and scientist). © *2012 National Association of Geoscience Teachers*. [DOI: 10.5408/11-218.1]

Key words: Native American, geoscience, education, culture, resource management, self-concept

INTRODUCTION

Native American nations in the United States have a unique legal status among indigenous peoples around the world. This status is related to the particular details of European colonization of North America over the last 500 years and the subsequent founding of the United States in the late 18th century. The legal status and history leads to continuing development challenges and opportunities rooted in the complex relationship between the United States federal government, individual state and local governments, and tribal authorities. The geosciences have been and still are often at the center of these relationships, especially as they pertain to the development of natural resources, tribal economics, and environmental stewardship. Importantly, however, Native Americans remain severely underrepresented in the sciences in general and in the geosciences specifically (National Science Foundation, 2007). In the present work, we evaluated the effectiveness of a culturally grounded, field-based geoscience education program for Native American students as a step toward increasing our understanding of the factors that motivate students to pursue formal education in the geosciences.

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[1]Department of Psychology & Center for Research in Mathematics and Science Education, San Diego State University, 5500 Campanile Dr., San Diego, California 92182-4611, USA
[2]Department of Geology & Geophysics, Room 202, Eller O&M Building, MS 3148 TAMU, Texas A&M University, College Station, Texas 77843-3148, USA
[3]The BRIDGE–YNS–InterTribal Youth, 874 Seacoast Dr., Imperial Beach, California 91932, USA
[a]Author to whom correspondence should be addressed. Electronic mail: unsworth@sciences.sdsu.edu.

The Problem: Resource Management and Educational Disparities

For Native American reservation communities in the United States, the geosciences have a bearing on future economic and social conditions as well as on sustainability and improvement of environmental conditions. According to data presented in Henson et al. (2007, p. 161), tribal lands in the contiguous lower 48 states of the United States contain 30% of the U.S. coal reserves, 40% of U.S. uranium deposits, and 4% of oil and natural gas deposits. Indian lands also have considerable freshwater, timber, and other agricultural resources. Federal government and history is replete with examples of resource dispossession over Native objections. The resulting need for Native American earth and environmental science expertise in reservation-based communities has been well-documented (Guerrero, 1992; Semken and Morgan, 1997; Grenier, 1998; Semken, 1999; Karr, 2000; Riggs and Semken, 2001; Marcus, 2002; Riggs and Riggs, 2003). However, the income and educational and social disparities between reservation communities and other American populations is striking, and Native Americans remain underrepresented in advanced education in general and in the sciences specifically.

For instance, Native American high school students have the second highest dropout rate (15.1%) compared to other ethnic groups (U.S. Department of Education, 2008). Other statistics show that adolescents who drop out of high school are 3.5 times more likely than those who complete high school to be imprisoned later in life (U.S. Department of Justice, 2002). In addition, high school dropouts earn only 37 cents for every dollar earned by someone with more education (U.S. Department of Education, 2006; Rouse, 2005), and students from low-income families are up to 6 times more likely to drop out of high school than those from higher income families (American Youth Policy Forum, n.d.). Poverty is very high among Native Americans on reservations—the highest of any ethnic group in the United States at 27% in 2006—with 39% of Native American children under the age of five living in poverty, which was almost twice the percentage for the rest of the United States (U.S. Department of Education, 2008), and an average per capita income for American Indians on reservations that is roughly one-third that of the broader American population. These statistics suggest that failure to complete high school can lead to a vicious cycle in which academic achievement, dropout rates, and poverty is perpetuated within families and communities.

There is also evidence for disparities in science education more specifically. For instance, the results from standardized tests reveal that many Native American children perform at or above the national average in science in grades 4 or 5, but by grades 8–10 are performing well below the national average (e.g., California Department of Education, 2008). In addition, although Native Americans make up roughly 1.7% of the American population, only 0.63% of all bachelor's degrees in science and engineering have gone to Native Americans in the last 10 years (National Science Foundation, 2007).

The Need for Culturally Grounded Earth Science Education

Underachievement and underrepresentation of Native Americans in science education are particularly surprising given evidence that Native American children tend to have highly sophisticated understandings of nature characterized by complex causal reasoning about interrelationships in nature (Cajete, 1999; Bang et al., 2007; Unsworth et al., 2012). Several educational researchers and scholars have argued that mainstream education in the United States reflects majority culture (i.e., Western) worldviews and provides little cultural support for Native American youth (e.g., Dehyle, 1992; Lee, 1995, 2001; Aikenhead, 1996; Crago et al., 1997; Cajete, 1999; McIntyre et al., 2001; Powers et al., 2003; Warren and Rosebery, 2007). For example, Aikenhead (1996) documents ways in which formal science classrooms are based on Western perspectives of science, which include an implicit view of humans as "apart from nature," while Bang et al. (2007) reported findings in which Native American adults and children are more likely than European American adults to think of humans as "a part of nature." Lack of cultural support for Native American students in science classrooms may underlie disparities between students' knowledge of science and their performance in science education. Educational interventions have the potential to produce cascading benefits, given that addressing problems in education may prevent escalation of other problems for young people and their families in the future.

Bang and Medin (2010) have documented successful outcomes for Native American youth who participate in a culturally based science education program; see also Denzin et al. (2008) and Kovach (2009) for examples involving the use of indigenous methodologies in other domains. Educational activities in this culturally based science education program were focused on science as a set of practices and orientations that include Native practices and worldviews. Native community members were active participants in the design and implementation of the program. Their contributions led to explicit use of Native worldviews throughout the program, and their participation highlighted the message that science is not just for non-Native people. This program also focused on ways in which school science is relevant to Native communities, which Aikenhead (1996) argued is critical for increasing Native students' level of engagement. Students completed surveys and semistructured interviews at the beginning and end of the program, and the results showed that students were more likely to conceptualize science as something that is done by Native people at the end of the program. Students were also more likely to think of science as a practice rather than as a set of facts to memorize at the end of the program. Importantly, while Bang and Medin's (2010) work documents the success of culturally based programs focused on science in general (with a heavier emphasis on biological science), there has been very little work focused on culturally based earth science programs more specifically.

THE PRESENT RESEARCH

The goal of the present research is to evaluate the effectiveness of a culturally based earth science program for Native American youth in California. This study is part of a larger effort to design and evaluate the effectiveness of educational programs built in partnership with Native American communities in Southern California and participating universities. The details of our program structure are described in detail elsewhere (Riggs et al., 2007), but in general, the overall program couples the efforts of Purdue University with local programs, faculty, and students at San Diego State University, the University of California, San Diego, and students and key San Diego County community colleges. We are also cooperating with Native American reservation communities in San Diego and Riverside Counties, and the educational programs and environmental offices that serve these communities. The design and assessment of this project explicitly engages many major community institutions, described as development "subsystems" by Smith (2000). Adopting his terminology, we have engaged the educational, social, and cultural systems in particular, with oversight, approval and guidance from tribal political and financial subsystems. Our program is structured to use our external funding from the National Science Foundation to leverage and create synergies between existing tribal programs and institutions such that we minimize the common developmental errors related to funding critical but temporary programs that depend on a continuous flow of external funds without building internal capacity. This program has formally united a well-established high school to college bridge program operated by and for local tribal communities—Intertribal Youth and Young Native Scholars (ITY/YNS)—and an early outreach program that involves outdoor science for younger children called Science Explorer's Clubs. Together these programs seek to create a culturally responsive recruitment and retention pipeline. The goal is to build sustainable programs rooted in the community that will persist long after external funding expires.

ITY/YNS Program

The ITY/YNS summer program is most directly amenable to testing assertions made in Riggs (2005) about the ability of field-based education programs to access and work with tribal, culturally held knowledge and thus best facilitate the bridging of the culture of geoscience and tribal culture for high-school age students, those most at risk for dropping out of the educational system and those poised on the threshold of college careers in geoscientific disciplines. The ITY/YNS program has been operating (with and without NSF support) since 2000, and there has always been an attempt to connect earth and environmental science education to Native culture and tradition and other issues on and around reservations. Formally trained Native and non-Native geologists and scientists provide instruction in this program using field- or place-based education and a Native American cultural framework. Activities are focused on cultural storytelling, rock formations, natural resource management, language, history, local water measurements, fault lines, sediments, native plant species, camping, tribal leadership activities, and drawing/artwork. Individual tribal practices and beliefs are highlighted through personal sharing by program participants, including both mentors and students, and through visitation to specific reservation communities in California. When activities take place on nonreservation lands, the history of Indigenous people who have inhabited—and who continue to inhabit—those lands is included in the activities. Two themes permeate the earth science instruction: 1) geoscience can be used to manage resources on or near Native reservations, and 2) science has always been a part of Native American tradition, history, and culture. These themes are consistent with Aikenhead's (1996) observations regarding the importance of highlighting the relevance of science within Native American cultural communities.

An example of a field-based activity in the program that highlighted the relevance of formal geoscience education for Native culture and resource management took place during an earth science camping trip near the San Luis Rey River on the reservation of the La Jolla Band of Luiseño Indians in southern California. Multiple activities occurred in the campsite space, which created a place-based foundation for the development of connections between the students, the cultural heritage of the Luiseño people, the natural resources in the area, and formal geoscience methodologies. After arriving at the campsite, students spent the afternoon swimming in the river and spent the evening engaged with a local tribal leader in storytelling and traditional singing. The next day, students learned about a proposal for a landfill to be situated at the foot of a mountain that is sacred to the Luiseño people. They also learned that this area is immediately adjacent to the San Luis Rey River. The students were charged with the task of deciding whether they should support the proposal for the location of the landfill. They discussed the aspects of the project that might affect local tribal communities, and they learned about the kinds of information they would need in order to support their decision. They engaged in formal geoscience activities in which they measured the amount of water flowing through the San Luis Rey River and examined rock formations to make predictions about the stability of the underlying bedrock. They also learned about plants and animals inhabiting the region, including the medicinal properties of some of those plants.

The goal of the formal science activities was more than simply inspiring an interest in geoscience methodology—it was to connect geoscience methodology to concepts of self, culture, and resource management using the field and place as a foundation and having students engage in critical thinking about real issues facing Native American reservations in southern California. Building these connections may help to bridge the path for Native students to pursue higher education in the geosciences and bring this expertise back to reservation communities by taking tribal resource and environmental management positions. An important step in exploring this possibility is to assess whether the program is successful in helping Native youth develop a perspective in which geoscience is relevant to themselves and their cultural community and whether an increase in perceived relevance of science is related to other concepts of science (e.g., attitudes toward science), concepts of self and culture, and motivation toward advanced education. This is the focus of the present research.

Pre- and Postprogram Assessments

In this research, Native American adolescents participating in the ITY/YNS program completed surveys at the beginning and end of the program. The surveys included questions that measured changes in and relationships between concepts of science, perceived relevance of school for Native tribes, motivation toward advanced education, and concepts of self and culture.

Measures for concepts of science were derived from Bang and Medin's (2010) research with Native American youth in the Midwest. These measures focused on the relevance of science to tribal communities, beliefs about self as scientist (i.e., the possibility that one will be a scientist as an adult), science/culture overlap (e.g., whether one can become a scientist and practice one's cultural way of life at the same time), concepts about where science is learned (i.e., science is something we only learn in a classroom), and attitude toward science. Measures for perceptions of culture focused on cultural pride and youths' perceptions of how much they know about their culture. Concepts of self was measured by focusing on self-confidence, self-descriptions, and a perceived interdependence between self and various domains, including nonbiological natural kinds (e.g., rocks, Earth, and Sun), biological natural kinds (plants and animals), social kinds (friends and family), and artifacts (e.g., computers).

The measures for concepts of self and culture are not comprehensive, though there was an open-ended question that provided youth with an opportunity to describe themselves in their own words. The self-description question used in this survey is based on a measure of self-construal known as the "twenty-statements" task in which participants are asked to complete the statement "I am …" 20 times as a list of 20 statements (Bond and Cheung, 1983; Cousins, 1989; Rhee et al., 1995). Using this task, Rhee et al. (1995) obtained evidence for cross-cultural differences in self-descriptors. Specifically, they found that European American adults used more trait descriptors (e.g., smart) and fewer social role descriptors (e.g., daughter) compared to Asian American and Korean adults. Although several theories of identity have been proposed in previous work and several measures have been developed (e.g., Erikson, 1950; Tajfel and Turner, 1979; Markus and Nurius, 1986; Oetting and Beauvais, 1990−1991; Marcia and Carpendale, 2004; Horse, 2005; McAdams, 2006; Packard and Conway, 2006; Phinney, 2006), the specific goal of the present research was to investigate changes in specific aspects of

TABLE I: Pre- and postprogram comparisons of scale item means.

Survey Constructs	Preprogram Mean[1], SD[2]	Postprogram Mean[1], SD[2]	T Values
Concepts of science			
Relevance of science to tribe			
Tribe uses science to manage resources	5.69, 1.99	7.44, 2.34	−2.73*
Tribe has been doing science for long time	5.69, 2.24	7.38, 3.20	−1.90[3]
Concepts of self as scientist			
Possibility of being a scientist as adult	3.38, 2.83	4.56, 3.39	−1.47
It would be easy for me to be a scientist	3.94, 2.79	4.88, 3.05	−1.54
Science-culture overlap			
Scientists and tribe view nature similarly	5.44, 2.39	5.19, 2.76	<1
Be a scientist and live cultural way of life	5.25, 2.46	6.69, 3.03	−1.68
Overlap in Western and Native views	3.21, 1.72	3.29, 2.20	<1
Science only learned in classroom	4.25, 1.92	3.44, 3.03	<1
Like science	6.00, 2.68	6.38, 3.07	<1
School learning is important to tribe	6.94, 2.70	7.69, 2.21	<1
Will go to college/university as an adult	8.13, 2.31	8.38, 2.80	<1
Self-confidence	8.00, 1.56	8.33, 1.68	<1
Perceptions of culture			
Perceived knowledge of culture	5.75, 1.65	5.56, 1.97	<1
Pride for culture	9.13, 1.46	9.69, 0.79	−1.54

Notes: [1]Higher values represent greater agreement with scale item; [2]standard deviation; [3]approaching significance; * $p < 0.05$.

self-concepts as well as associations between these aspects and other constructs.

Predictions

Given the program's focus on the ways in which geoscience can be used to manage resources on Native lands and the perspective that science has always been a part of Native American tradition, history, and culture, it was expected that after completing the program, youth would be more likely to agree with statements that tribes use science to manage natural resources and that tribes have always used science. However, it was not clear whether these conceptions regarding the relevance of science to tribal communities would be related to other views of science, concepts of self and culture, and motivation toward higher education, and whether we would observe changes in these other factors as a function of participation in the program.

METHODS

Participants

Sixteen Native American adolescents (10 females, 6 males) completed the pre- and postprogram surveys. The ages ranged from 12 to 16, and the mean age was 14. The adolescents were from communities throughout California and other southwestern states, including Death Valley Indian Community (Death Valley Timbisha Shoshone Band of California), Big Pine Reservation (Big Pine Band of Owens Valley Paiute-Shoshone Indians), Lone Pine Paiute Shoshone Reservation, La Jolla Reservation, the Fort Independence Indian Reservation, the Pyramid Lake Paiute tribe, the Fort Mojave Indian tribe, the Navajo Nation and the San Diego urban Indian community.

Materials

The survey included questions that measured concepts of self and culture, concepts of science, perceived relevance of school for Native tribes, and motivation toward advanced education (see the supplemental materials for the survey instrument; available at: http://dx.doi.org/10.5408/11-218s1). Data regarding participants' gender, age, grade level, and tribal affiliation were also collected. The majority of the questions involved Likert scale ratings of agreement with particular statements (see Table I for a complete list of scale items). For this reason, participants completed two practice questions involving 10-point Likert scale ratings in order to gain familiarity using these scales (see the practice questions in the supplemental materials). This 10-point scale was used for all the scale items in the present research.

Scale items measuring perceptions of culture included participants' perceptions of their own knowledge of their culture and their level of pride in their culture. Concepts of self were measured by including a scale item for assessing self-confidence, an open-ended question in which youth provide self-descriptions, and a question measuring perceived interdependence between self and nonbiological natural kinds, biological natural kinds, social kinds, and artifacts (the list was generated by the authors of this manuscript; see Table II for the complete list). In the latter question, participants were asked to "circle any of the following things that make you who you are."

The measure of self-confidence was used in order to examine participants' evaluation of the self and possible changes in these evaluations. Previous research has shown that global self-esteem (i.e., overall sense of self-worth) is more stable over time and is therefore less likely to change as a function of an intervention (see Blascovich and Tomaka,

TABLE II: Pre- and postprogram comparisons for proportion of participants who circled items that make them who they are.

Items	Preprogram Mean[1], SD[2]	Postprogram Mean[1], SD[2]	T Values
Earth	0.31, 0.48	0.69, 0.48	−3.00**
Rocks	0.06, 0.25	0.31, 0.48	−2.24*
Land	0.13, 0.34	0.44, 0.51	−2.07[3]
Sky	0.31, 0.48	0.50, 0.52	−1.86[3]
Water	0.38, 0.50	0.63, 0.50	−1.73
Rivers	0.19, 0.40	0.31, 0.48	−1.00
Ocean, sun, coyotes, birds	0.31, 0.48	0.31, 0.48	<1
Clouds, plants	0.13, 0.34	0.31, 0.48	−1.38
Corn	0.06, 0.25	0.00, 0.00	1.00
Turtles, cars	0.13, 0.34	0.13, 0.34	<1
Fish	0.00, 0.00	0.06, 0.25	−1.00
Oranges, bread	0.06, 0.25	0.00, 0.00	1.00
Hamburgers	0.19, 0.40	0.19, 0.40	<1
Chocolate	0.06, 0.25	0.13, 0.34	−1.00
Family	0.69, 0.48	0.75, 0.45	<1
Friends	0.56, 0.51	0.69, 0.48	−1.00
Acorns, scissors	0.00, 0.00	0.00, 0.00	<1
Computers	0.25, 0.45	0.06, 0.25	1.86[3]

Notes: [1]Higher values represent greater agreement with scale item; [2]standard deviation; [3]approaching significance; * $p < 0.05$, ** $p < 0.01$.

1991). Evaluation of self-confidence, which typically involves more specific evaluation of one's competence, skill, or ability (Crocker and Major, 1989) might be more likely to change as a function of an intervention. A single item measure was used rather than a multi-item measure, given the practical constraints of the present research (i.e., limited time to complete the surveys). Robins et al. (2001) describe the benefit of using single-item measures, particularly when constructs are not considered to be multifaceted, which is less likely for measuring more general rather than more domain-specific constructs, and when researchers are balancing psychometric concerns with practical constraints. Robins et al. (2001) found substantial correspondence between a single-item and multi-item measures of self-esteem.

The open-ended measure for self-descriptions was based on an adaptation of the twenty-statements test, which has been used to measure cross-cultural differences in identity (e.g., Rhee et al., 1995). Typically, participants are asked to complete the statement "I am . . ." 20 times as a list of 20 statements. Given time constraints for completing the surveys, in both the pre- and postprogram survey, participants were asked to complete the statement three times (i.e., as a list of three statements) rather than 20 times.

Survey questions assessing concepts of science included scale items measuring perceived relevance of science to tribal communities and concepts of self as scientist, as well as a Venn diagram item measuring science/culture overlap. Responses to the science/culture Venn diagram item were recoded into a scale from 1 to 7, with "1" representing nonoverlap between Western science views and Native views and "7" representing 90% overlap. Other concepts of science were also measured using scale items, including where science is learned and attitudes toward science. Scale items measuring perceived relevance of school for Native tribes and motivation toward advanced education were the final constructs measured in this study.[1]

Procedure

Participants completed the preprogram surveys on the first day of the ITY/YNS program before any of the instruction or activities began. They were told that participation was completely voluntary and that there were no right or wrong answers. They completed postprogram surveys on the final day of the program after the last activity. The postprogram surveys were identical to the preprogram surveys. Participants were told that while many of the questions might seem familiar, they should respond on the basis of what they think and how they feel at that moment. Participants were reminded that there were no right or wrong responses. Surveys took approximately 20 minutes to complete.

RESULTS

The results are first reported for pre- and postprogram comparisons and then for relationships between the constructs showing change as a function of the ITY/YNS program. Given the small sample sizes, effect sizes are reported for those that approach significance and for subgroup comparisons (e.g., comparisons between participants who did and did not circle, say, earth and rocks as things that make them who they are).

[1] Other constructs were also measured in the survey as part of an exploratory pilot study, the focus of which is beyond the scope of the present paper.

TABLE III: Correlations between relevance of science and other constructs.

Survey Constructs	Tribe Uses Science to Manage Resources	Tribe Doing Science for Long Time
Concepts of science		
Relevance of science to tribe		
Tribe uses science to manage resources	–	0.73**
Tribe has been doing science for long time	0.73**	–
Concepts of self as scientist		
Possibility of being a scientist as adult	0.17	0.44[1]
It would be easy for me to be scientist	0.25	0.27
Science-culture overlap		
Scientists and tribe view nature similarly	0.01	0.12
Be a scientist and live cultural way of life	0.30	0.26
Overlap in Western and Native views	0.12	0.28
Science only learned in classroom	−0.16	−0.16
Like science	−0.14	0.05
School learning is important to tribe	0.39	0.64**
Will go to college/university as an adult	0.63*	0.59*
Self-confidence	0.73**	0.76**
Perceptions of culture		
Perceived knowledge of culture	0.25	0.03
Pride for culture	0.40	0.08

Notes: [1]Approaching significance; * $p < 0.05$; ** $p < 0.01$.

Pre- and Postprogram Comparisons

Comparisons of responses to Likert scale items at the beginning and end of the ITY/YNS programs showed that students were significantly more likely to agree with the statement that their tribe uses science to manage their natural resources at the end of the program (results for all Likert scale items can be seen in Table I). Students were also more likely to agree with the statement that their tribe has been doing science for a long time. While this difference only approached significance, the effect size was large (i.e., Cohen's D = 0.61), with approximately 38% of nonoverlap between the two distributions of responses to this item (Cohen, 1988). Differences in the responses to the other Likert scale items did not approach significance.

Comparisons between pre- and postprogram responses showed that students were significantly more likely to circle "earth" and "rocks" as things that make them who they are at the end of the programs (see Table II for responses to this item). Students were also more likely to circle "land" and "sky" as things that make them who they are. These differences only approached significance, but the effect size was large for the difference in circling "land" (Cohen's D = 0.71, approximately 43% nonoverlap between pre- and postprogram response distributions) and medium for the difference in circling "sky" (Cohen's D = 0.38, approximately 17% nonoverlap between pre- and postprogram response distributions). Students were also less likely to circle "computers" at the end of the program, though this difference only approached significance (Cohen's D = 0.52, approximately 33% nonoverlap between pre- and postprogram response distributions).

An examination of the responses to the self-description task shows that participants were more likely to spontaneously describe themselves as "strong" at the end of the program (38% of students) compared to the beginning of the program (6% of students), $t(15) = 2.08$, SE = 0.15, $p = 0.06$ (Cohen's D = 0.81, indicating a large effect size with approximately 47% nonoverlap between pre- and postprogram response distributions). Other responses included: Native/Indian, smart, funny, outgoing, short, pretty, young, happy, proud, Navajo, kind, hungry, tired, small, excited, a cheerleader, a volleyball player, a person who likes to hang out with friends, a leader, a skater, fun, nice, courageous, twelve, a golfer, sixteen, a student, a cool person, good at beading, quiet, athletic, honest, beautiful, a BMX rider, a sister, a woman, a friend, in awe of the world, and connected. These responses did not vary systematically across pre- and postprogram surveys. One student wrote "scientist" at the end of the program.

Relationships Between the Constructs

Analyses were conducted in the postprogram survey data to examine relationships between constructs showing statistically significant changes as a function of the ITY/YNS program and other constructs. Correlation analyses were conducted in order to examine relationships between the relevance of science to tribal communities and other constructs (see Table III). The results showed that students who were more likely to agree with statements that their tribe uses science to manage their natural resources and that their tribe has been doing science for a long time were significantly more likely to agree with statements that they will go to college or university when they are adults and that they are confident in themselves. In addition, students who were more likely to agree with the statement that their tribe has been doing science for a long time were also more likely

TABLE IV: Comparisons between participants who did versus did not circle Earth as something that makes them who they are.

Survey Constructs	Circled Mean,[1] SD[2] (N = 11)	Did Not Circle Mean,[1] SD[2] (N = 5)	T Values
Concepts of science			
Relevance of science to tribe			
Tribe uses science to manage resources	7.64, 2.46	7.00, 2.24	<1
Tribe has been doing science for long time	8.27, 2.33	5.40, 4.22	1.78
Concepts of self as scientist			
Possibility of being a scientist as adult	5.73, 3.47	2.00, 1.00	2.32*
It would be easy for me to be scientist	5.45, 3.50	3.60, 1.14	1.14
Science-culture overlap			
Scientists and tribe view nature similarly	5.55, 3.11	4.40, 1.82	<1
Be a scientist and live cultural way of life	7.27, 2.90	5.40, 3.21	1.16
Overlap in Western and Native views	3.70, 2.41	2.20, 1.10	1.31
Science only learned in classroom	3.18, 3.13	4.00, 3.08	<1
Like science	6.64, 3.59	5.80, 1.64	<1
School learning is important to tribe	6.94, 2.70	7.69, 2.21	<1
Will go to college/university as an adult	8.13, 2.31	8.38, 2.80	<1
Self-confidence	8.00, 1.56	8.33, 1.68	<1
Perceptions of culture			
Perceived knowledge of culture	5.75, 1.65	5.56, 1.97	<1
Pride for culture	9.13, 1.46	9.69, .79	–1.54

Notes: [1]Higher values represent greater agreement with scale item; [2]standard deviation; * $p < 0.05$.

to agree with the statement that the things they can learn in school are important to their tribe. The two items used to measure science epistemology were also highly correlated with each other.

Comparisons were conducted to examine differences between participants who did and did not circle "earth" as things that make them who they are (see Table IV). The results showed that participants who circled "earth" were significantly more likely than participants who did not to agree with the statement that there was a strong possibility that they will be a scientist when they are adults. The effect size was very large (Cohen's D = 1.47, approximately 69% nonoverlap between the two distributions).

DISCUSSION

The results from the pre- and postprogram surveys showed that students were more likely to agree that science is relevant to their tribal communities at the end of the cultural and field-based geoscience education taking place during the ITY/YNS program. In addition, agreement that science is relevant to tribal communities was related to reports of higher self-confidence, stronger agreement that what can be learned in school is important to one's tribe, and stronger agreement with the statement that they will go to college or university as adults. At the end of the program, youth were also more likely to indicate that they perceive interdependence between self and both earth and rocks (above and beyond a range of possible items to choose from, including plants, animals, food, and artifacts) and they were more likely to describe themselves as being strong. The results also showed that students who indicate that they perceive interdependence between self and earth are more likely to agree that they will be scientists when they are adults.

As mentioned in the *Introduction*, it was expected that at the end of the program youth would be more likely to agree that tribes use science to manage natural resources and that tribes have always used science. Changes in these items reveal the effectiveness of the program in meeting one of its primary goals. However, it was not clear whether we would observe changes in other items or whether we would see relationships between factors. We did observe changes in responses regarding concepts of self. An increase in perceived interdependence between self and earth/rocks over the course of the ITY/YNS program that is also correlated with the likelihood for youth to think that they will be scientists as adults may be related to and maybe even extend implications for changes observed regarding the relevance of science for tribes. Specifically, changes in perceived relevance of science for tribes may reflect a larger network of connections being made between concepts of self, earth, community, and science. This possibility is also supported by positive correlations between perceived relevance of science for tribes, perceived relevance of school for tribes, self-confidence, and motivation toward advanced education.

Importantly, however, the measures for concepts of self used in the present research are not comprehensive. Furthermore, the nature of the concepts of earth and rocks and the conceptual understanding of perceived interdependence between self and earth/rocks are unclear. More research is needed to better understand youths' concepts when they respond that earth and rocks (and even land) make them who they are and whether their responses actually reflect perceived interdependence between themselves and the earth. If so, it would also be important to determine whether youth are conceptualizing earth more abstractly (e.g., as a globe) or more concretely (e.g., as soil, water, or plants). At a minimum, the results from the present research provide a first step toward addressing Bang and Medin's (2010) call for research that explores the relationship between identities and science epistemologies by showing that culturally based earth science programs designed for Native American youth can facilitate associations between concepts of self, science, and tribe. Future research should build on the present findings by expanding the measurement of identities and earth science.

Importantly, all of the items used in the survey are based on youths' self-reports regarding their ideas about themselves and their level of agreement with particular statements. As a result, it is unclear whether the concepts themselves are changing (i.e., concepts of science and concepts of self), or whether youth already possessed these concepts before the beginning of the ITY/YNS program but become more likely to respond in ways that are more consistent with what they already think. In either case, the implications for youth should be positive. For example, we could predict that youth will feel more motivated to base future decisions about education, community-involvement, and career choice on concepts of interrelationship between concepts of self, science, culture, and education if their concepts are changing, but also if youth are becoming more comfortable expressing their ideas or if their concepts are becoming more explicit. In future research, we plan to include measures that assess concepts directly and indirectly in order to examine differential effects of changing concepts versus changes in youths' likelihood to self-report what they already think. In addition, we hope to follow-up with students longitudinally in order to determine whether their self-reported motivation to pursue higher education and science-related occupations is consistent with their actual decisions and behaviors. Longitudinal research will also help us to assess whether youth who ultimately go on to pursue advanced education in the sciences return to their communities to work toward supporting the sovereign interests of their tribes.

An additional limitation in the present research is the small sample size. Effects of the program were large enough to be easily observable in spite of the small sample size, suggesting that the effects of the program are substantive. Calculations of Cohen's D effect sizes support this conclusion, revealing medium to large effect sizes for differences that were significant or that approached significance. However, changes in many of the constructs that did not reach significance were often trending in ways that were similar to changes that reached significance. An examination of Table I shows that some aspects of perceived science-culture overlap trended toward change over the course of the ITY/YNS program. For example, compared to the beginning of the program, at the end of the program students appeared to be less likely to agree that science is only learned in the classroom, more likely to report that they like science, and more likely to report that they are proud of their culture. In addition, at the end of the program, students appeared to exhibit stronger agreement with the statement that they could be a scientist and live their cultural way of life. Interestingly, aspects of perceived science-culture overlap that involved viewing Western science and Native views as similar did not trend toward the direction of change, and levels of agreement with these items remained weak. Together with findings for perceived relevance of science, these trends suggest that even when students are connecting science with culture, they may still consider science and culture as distinct from one another. A larger sample size would help to determine whether these differences are reliable or whether they are simply due to chance. A larger sample size would also allow for more specific comparisons between youth from different tribes or even between youth belonging to the same tribe. Native tribes are not homogeneous, and our goal is to focus on both between-tribe and within-tribe variation in future research as a way of better understanding the way in which individual-level factors interact with community-level and program-level factors.

Overall, the results from the present research provide an important step in a larger program of work that seeks to create pathways for Native American students as they navigate multiple cultural perspectives in pursuit of earth science education. The present findings provide support for Aikenhead's (1996) observations regarding the importance of highlighting the relevance of science within Native American cultural communities by showing that culturally grounded earth science programs designed for Native American youth can facilitate changes in Native American adolescents' self-reports regarding their concepts of self, science, and community.

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