# Broadening the Participation of Native Americans in Earth Science

by

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ABSTRACT

Climate change is not a thing of the future. Indigenous people are being affected by climate changes now. Native American Earth scientists could help Native communities deal with both climate change and environmental pollution issues, but are noticeably lacking in Earth Science degree programs. The Earth Sciences produce the lowest percentage of minority scientists when compared with other science and engineering fields.

Twenty semi-structured interviews were gathered from American Indian/ Alaska Native Earth Scientists and program directors who work directly with Native students to broaden participation in the field. Data was analyzed using qualitative methods and constant comparison analysis. Barriers Native students faced in this field are discussed, as well as supports which go the furthest in assisting achievement of higher education goals. Program directors give insight into building pathways and programs to encourage Native student participation and success in Earth Science degree programs.

Factors which impede obtaining a college degree include financial barriers, pressures from familial obligations, and health issues. Factors which impede the decision to study Earth Science include unfamiliarity with geoscience as a field of study and career choice, the uninviting nature of Earth Science as a profession, and curriculum that is irrelevant to the practical needs of Native communities or courses which are inaccessible geographically. Factors which impede progress that are embedded in Earth Science programs include educational preparation, academic information and counseling and the prevalence

of a Western scientific perspective to the exclusion of all other perspectives. Intradepartmental relationships also pose barriers to the success of some students, particularly those who are non-traditional students (53%) or women (80%).

Factors which support degree completion include financial assistance, mentors and mentoring, and research experiences. Earth scientists can begin broaden participation by engaging in *community-inspired research*, which stems from the needs of a community and is developed in collaboration with it. Designed to be useful in meeting the needs of the community, it should include using members of the community to help gather and analyze data. These community members could be students or potential students who might be persuaded to pursue an Earth Science degree.

There are those who go out of their way to help us along our pathways. These guides are our mentors. Whether our contact encompasses minutes, hours, days, years, or even decades, the truth became inalienably clear during the course of this work: *it only takes one*. It only takes one mentor to move your life in a direction you had not dreamed possible. You did not dream it possible because you did not know it existed, but s/he did. I have been blessed with many mentors during my journey towards my doctorate. This document is dedicated to those mentors.

First, the dedicated leadership of SACNAS, who scooped me up and carried me along, always whispering "Si, se puede". It was at the 2008 SACNAS conference where the idea for this dissertation was born. My thanks go to Maria Teresa Velez, my McNair advisor, who always makes me believe in myself and tells me how proud she is of me every time I see her, and Aaron Velasco, geologist and past president of SACNAS who always remembers me and gives me a hug, no matter how busy he is. I thank you.

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# Chapter 1

## INTRODUCTION

Climate change is no longer an issue that may happen at some point in the future; it is affecting the people of the Northern lands of ice and snow right now (Snowchange, 2005). Seven villages of Alaska Natives have moved because the coastline that they have lived on for centuries has flooded or eroded due to rising tide from melting ice sheets. In one example, the United States Geological Survey (USGS) reports that erosion rates along the Beaufort Sea, which meets the north shore of the Alaska coastline, have climbed from 20 feet per year between the mid 1950s and late 1970s, to 28 feet per year in the next period ending in the early 2000s, and is currently being measured at a rate of 45 feet of disappearing shoreline per year between 2002 and 2007 (Jones, Arp, Jorgenson, Hinkel, Schmutz & Flint, 2009).

Caribou can no longer reach their mating grounds as ice bridges have thawed due to rising temperatures. Polar bears can no longer live and breed on the ice shelves that are their habitat, and so are seeking food in Native villages and behaving in unaccustomed manners. It is estimated that Polar bears may be extinct in fifty years. Subsistence hunting has been disrupted as thinning ice sheets become too fragile to hold either hunters or prey, causing natives to go without traditional food supplies. Permanently frozen tundra is now permanently thawed, and Native fishermen report black spots on the insides of the fish they can catch (Huntington, 2008)…the way of life for people of the north is changing, and if they are to survive they must, as always, adapt. Alaska Natives, and other

Indigenous peoples around the globe, are being directly affected by the consequences of global warming.

At the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) conference, October 2008, the focus was on global climate change. As part of a day-long special session, geology and environmental science students were presented with a comprehensive look at the problems facing the Earth due to global warming. Apart from the detailed scientific information on what is being done to study the problem, the session concluded with experiential testimony from tribal leaders. At the end of their presentation, tribal leaders expressed a desire for Native voices to be heard during talks about climate change. They asked for our (Earth Science community) help.

One way for Native voices to be heard by the world community is for Native people to seek advanced degrees in science and become recognized as *scientists* within the Western system of education. I do not mean this in a way that Native students need be assimilated into the culture of Western science, but rather that Native students study Western science in such a manner that they are able to serve as an involved translator between the needs of their community and their chosen field of study. In this way the Earth Sciences can be helped to transform into a discipline that thinks in a more holistic, global manner.

An example of this type of transformation can be seen in the area of Technosocial modeling. The term *Technosocial* describes that space where technology and social practice intersect, for example in phenomena like mobile internet technology, Facebook, and Twitter. In *Technosocial modeling*, complex

computer programs are developed to predict the interactions of technology and society within the context of a defined problem. For example, at the Pacific Northwest National Laboratory, a team of scientists are combining both physical and human factors in the areas of energy, security, and the environment to attempt to predict the impact of climate change on power grids in the cities of Portland, Oregon and Phoenix, Arizona (Pacific Northwest National Laboratory, 2008). Even in this example, however**,** the choice of cities investigated reflects the interests of the research group and its sponsors, the United States Department of Energy, not the citizens whose lifeways are immediately threatened.

The truth is that the various fields of Earth Science need new perspectives and ideas. We need out-of-the-box thinkers, unfettered by the chains of the "proper" (White) ways to think about scientific problems if we, as people of the planet, are going to be able to make enough changes to ameliorate the damages that have already been done. Earth Science, as a field of study, also needs Native scientists who are willing to live and work in their native homelands year-round, not just visit and make observations during summer breaks, as is common scientific practice today. For example, Richard Glenn, Iñupiaq geologist, tells the story of how his insider knowledge may have saved the lives of members of an inexperienced scientific expedition to an Alaska ice shelf (National Science Digital Library):

> I once led a field trip out onto our frozen ocean with researchers trained in interpreting sea ice from satellites. These folks had little experience actually being on sea ice. Some were experts in recognizing multiyear sea

> ice from space, yet they had to be told when they were traveling on it in the 'real world. I led a few of them to the ice edge, where things are more active. I cautioned them about what we are all taught as young Iñupiat hunters—that we have to watch wind, currents, and ice conditions, as they are always changing. When we reported back to the rest of the group, the researchers wanted to return with a few of their colleagues. I led them along the same trail. Upon nearing the edge, I slowed down. Where we had just visited an hour earlier had broken off and was floating away. The formerly emboldened researchers looked at me with eyes wide like golf balls. What is taught to most teenagers who hunt on the ice was suddenly very important to these folks who look at ice from the vantage of satellites.

Many observations of climate changes have already been made by Native peoples (Alaska Native Science Commission), but those observations are rarely disseminated to the rest of the world because they are not valued as knowledge by the academic community, and consequently do not find their way to widespread publication.

At a conference session a few days later, a small gathering of geologists began discussing the availability of their internship programs for which they have tried to recruit Native students. Although some of these special summer programs provide transportation costs, housing, meals, and a small stipend, it has been difficult to find students interested in studying Earth Science. The scientists running these programs, who are trying to encourage Native students to pursue

Earth Science as a field of study, are frustrated because they don't know why students are not coming.

While listening to both sides, it seemed apparent to me that the "leaky pipeline" that educators use as an analogy for attrition rates of students from secondary school into college and graduate programs is not leaking but rather, at least in the case of Earth Sciences and Native students, has never been constructed. The use of the word "pipeline" is problematic. A pipeline describes a series of long tubes meant to directly transport a passive substance from the place of origin to the end destination. A pipeline implies that there is no choice, no getting out, unless the substance can find a hole to "leak" through. This is simply not what happens with students. Students are not passive. Students have choices. Just because a student begins college with the idea that s/he will get a degree in a certain field of study does not mean s/he will end at the destination at the end of the pipeline. For this reason I will use the idea of building a pathway that students can choose to continue upon or abandon.

This study seeks to determine what factors of the unique relationship between American Indians, Alaska Natives, and the Western Modern science field known as *geoscience* are standing in the way of welcoming Native peoples into Earth Science careers. Note: I use the terms geoscience and Earth Science interchangeably and make no distinction between these two names for the same broad field of research and careers. I also use the terms Native American and American Indian interchangeably, while recognizing that many different nations are being characterized by this political term.

Chapter 2

# LITERATURE REVIEW

## Environmental Stewardship

### Introduction.

There are 4.3 million Native Americans in the United States. Represented are 562 federally recognized tribes, with 227 of them located in Alaska. Indian owned reservations include 56 million acres of land in 34 states. This 1.5% of the population own and administer 5% of the land, which contains 10% of the country's energy reserves and 27% of the water of the United States (Castillo, 2004).

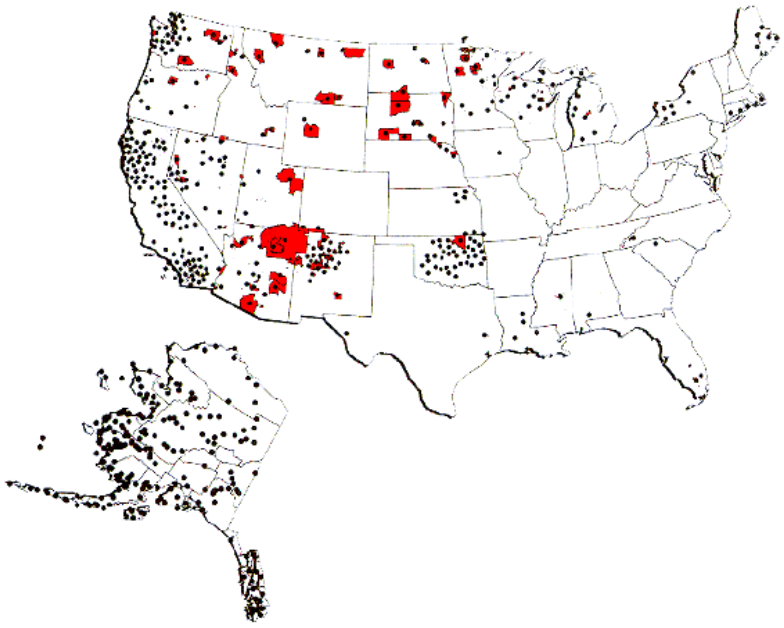


*Figure 1*. Locations of American Indian and Alaska Native lands in the United States.

http://apps1.eere.energy.gov/state_energy_program/update/printer_friendly.cfm?volume=71.

Land is traditionally very important to American Indian cultural identity, way of life, and knowledge (Clarkson, Morrisette & Regallet, 1992). Much of the land Indians live on today is in remote, rural areas unsuitable for agriculture. As a result, tribal economies frequently depend on ranching, forestry and resource extraction. For example, 65% of the known uranium deposits, 35% of the strippable coal, and 5% of natural gas in the United States is located on reservations or treaty lands (Clarkson, Morrissette, & Régallet, 1992). In addition, tribal nations are often economically pressured to accept nuclear waste for disposal (Grossman, 2006; Knudsen, 1996; Lacey, 2004). Some of these activities have had devastating environmental effects.

**Stewardship and worldview.**

American Indians have a unique relationship with the land. From *Our Responsibility to the Seventh Generation: Indigenous Peoples and Sustainable Development* by Linda Clarkson, Vern Morrissette and Gabriel Régallet (1992):

> There is a teaching passed down from our ancestors that crystallizes our sense of responsibility and our relationship to the earth that arises out of the original law. It is said that we are placed on the earth (our Mother) to be the caretakers of all that is here. We are instructed to deal with the plants, animals, minerals, human beings and all life, as if they were a part of ourselves. Because we are a part of Creation, we cannot differentiate or separate ourselves from the rest of the earth. The way in which we interact with the earth, how we utilize the plants, animals and the mineral gifts, should be carried out with the seventh generation in mind. We cannot

simply think of ourselves and our survival; each generation has a responsibility to ensure the survival for the seventh generation (12).

As guardians of the land for future generations, tribes are charged with stewardship of land and resources. *Stewards*, however, do not own that which they service and protect. The use of this word reflects a basic difference in the worldviews of Indigenous peoples and Western thought. Indigenous worldviews do not reflect the idea that things in nature, including land, are owned, whereas Western worldview is based on the ideas of individual ownership of property.

Indigenous worldviews are guided by spirituality and survival (Brayboy & Castagno, 2008). Indigenous worldviews do not believe that gifts from the earth are "resources" to be extracted in mass quantities and exported, but rather are to be used only as the need arises, with care and thought to what will happen to the land, animals and future generations (Arden & Wall, 1990; Clarkson, Morrisette & Regallet, 1992; Gallhofer, Gibson, Haslam, McNicholas & Takiari, 2000; Van de Fliert, 1994 ) . In Indigenous ways of thinking, the observer and observed are not different or separate (Kawagley, 2006). If the Earth Sciences were to begin to incorporate some of these ideas into the discipline, a new way of thinking about climate change might emerge.

**Indigenous science and Western science.**

Native peoples are suspicious of the intentions of Western scientists, some of whom have been responsible for the promulgation of atrocities against Native peoples (Kaomea, 2003; Lomawaima, 2008; Smith, 1999; Swisher, 1998; Tuck, 2009; Wilson, 2008). Western Modern scientists are suspicious of those things

that are *known* seemingly without "proper", rigorous testing. The irony is that Western Modern scientists themselves (and by *scientists* I am defining the term to mean those who have been trained in one of the Western Modern scientific hard sciences), at least the Earth scientists that I know, would not consider people like Dr. Albert Jenks or Dr. Ales Hrdlicka, anthropologists responsible for hair and scratch tests to determine full-bloodedness in American Indians, to be scientists (Beaulieu, 1984).

Indigenous Knowledge Systems are generally based on centuries of observations, experiences, and analysis by Native peoples and have been more rigorously tested (by life's realities) than any scientist can hope to accomplish in one short career (Sefa-Dei, 2002). Much like the idea of transdisciplinary initiatives popular in some academic institutions that are designed to meld two academic disciplines together and transform them into something new, Western Modern science and Indigenous science could produce a new, synergistic way of looking at global problems. A perfect case in point is the problem of climate change, which Alaska Natives are experiencing first hand.

American Indian peoples had well developed science knowledge in the fields of agriculture, astronomy, ecology and medicine well before contact with Whites. These Native sciences were built on the processes of rational observation of the natural world, classification, and problem solving (Battiste, 2002; Cajete, 1986). Some scientific disciplines have begun to value the knowledge Native peoples can contribute to the field, in particular medicine, resource management, meteorology and biology (James, 2001). Although many Earth scientists rely on

Native peoples and their knowledge when working in the field, it has been my experience that they typically portray Native peoples as guides and burden bearers, not scientific equals, when discussing research with students (Arnold, 2000; Bielawski, 1996).

Western organizational worldviews which feature specialization, standardization, compartmentalization and systematization are often in direct conflict with the organizational worldviews of Indigenous societies which often feature collective decision-making, extended kinship structures, ascribed authority vested in elders and flexible notions of time (Barnhardt, 2002). The Alaska Rural Systemic Initiative (AKRSI), a ten-year collaborative program between the University of Alaska Fairbanks and Native communities, produced a set of educational initiatives which systematically documented Indigenous Knowledge Systems of Alaska Native peoples and developed ways of incorporating that knowledge into the formal education system (Barnhardt, 2009).

In Alaska, a model was developed in the *Handbook for Culturally Responsive Science Curriculum* written for Alaska schools as a product of AKRSI (see Figure 2). Sidney Stephens explains: the process of transforming Western science with Native knowledge…"has to do with accessing cultural information, correlating that information with science skills and concepts, adjusting teaching strategies to make a place for such knowledge, and coming to value a new perspective" (Stephens, 2000). As the figure suggests, even though Western Modern Science and Indigenous Knowledge Systems (Traditional Native Knowledge in the diagram) have their differences, there are areas of overlap

between the two ways of thinking and doing science. Perhaps this model might serve as a seed to begin the transformation of Earth Science itself.

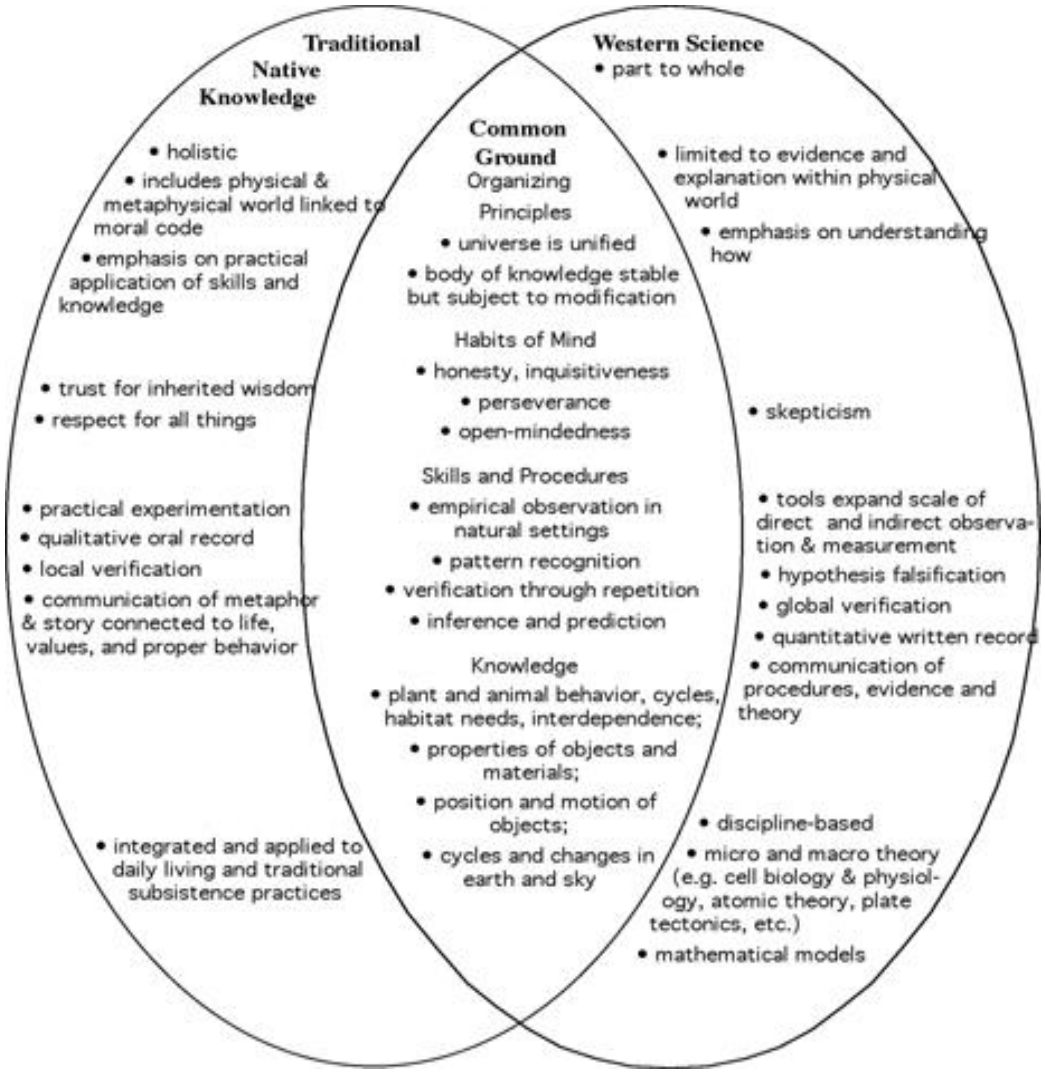



*Figure 2*. Diagram of relationship between traditional Native Knowledge and Western Science

From *Handbook for Culturally Responsive Science Curriculum (Stephens, 2000).*pg. 11

**Land, Water, and Natural Resource Extraction.**

Land is very important to indigenous peoples. American Indian lands have been constantly harvested of natural resources by mining companies, with serious impact to the people. A recent article by Brenda Norrell (2009) outlines just a few of the problems mining has caused on American Indian lands. In October, 2009, over 250 representatives of Indigenous peoples gathered at the Indigenous Uranium Forum in Acoma Pueblo, New Mexico. The purpose of the gathering was to both fight against uranium mining on Native land, and to protect the sacred site of Mount Taylor.

Uranium mining in the Grants Uranium Belt on the Navajo Nation began during the Cold War, where Navajo workers were sent to work in the mines without protective gear. In addition to direct exposure, mining dust invaded food supplies and killed inhabitants of both the Laguna Pueblo and Acoma Pueblo. Hundreds of Navajos living in Red Valley, Cove, and Monument Valley, Arizona have died from cancers which can be linked to uranium mining (Norrell, 2009).

On July 16, 1979, the United Nuclear Corporation had a nuclear spill which poisoned the lands and waters of the Navajo, including the Rio Puerco. This incident, larger than that of Three Mile Island, spewed 1,100 tons of uranium mining waste – *tailings* – and 100 million gallons of radioactive water through a crack in the mud-pack dam designed to contain them. Three hours after the incident radioactivity was monitored in Gallup, New Mexico 50 miles away. At this time the Rio Puerco River exhibited radioactivity levels 7,000 times the allowable standard. One month after the spill occurred, only 50 of the 1,100 tons

of spilled tailings had been cleaned up. Media reports outside the area reported that the spill posed “no immediate health hazard”, and that the area was “sparsely populated” (Johansen, 1997).

Due to the contaminant in the river water, lambs and calves have been born without limbs and cattle have developed sores and died (Johansen, 1997). Water, it should be noted, does not stay in a river, but rather the river is a surface expression of the local water table, which undoubtedly has also been contaminated with nuclear waste pollution.

Even though mining was banned on the Navajo Nation in 2005, the *checkerboard pattern* land distribution on its outer borders allows mining to continue on public lands. The checker board pattern in land ownership is the result of federal land grants in the 1800s which divided much of the western United States into 40 acre parcels. Railroads were then granted every other parcel along the railway. Private owners could posses the alternate parcels. The result is a checkerboard pattern of private, reservation, and government owned lands which exist in western states still today (Henry, 1945). In addition, mining companies have petitioned to open new uranium mines at the Havasupai’s sacred Red Butte on the south rim of the Grand Canyon (Ahni, 2011).

Both the Navajo lands around the four corners region, and the Badlands of South Dakota were suggested to be designated as National Sacrifice Areas by the National Academy of Science, made part of the Federal Energy Departments Project Independence in 1974, and targeted for increased mining (Churchill, 2002). There are currently more than 1,000 abandoned open-pit uranium mines

and more than 10,000 abandoned exploratory uranium wells in the Great Plains. Charmaine White Face, Oglala  Tetuwan, coordinator of Defenders of the Black Hills, also claims that the radioactivity of the area around Mount Rushmore is being concealed by state leaders of South Dakota for fears of losing tourism (Norrell, 2009).

The cost for cleaning up the uranium mining contamination in the Plains area alone will likely run into the billions of dollars. According to Charmaine White Face, the United States government must clean up the existing damage before they can issue any new permits in the area (Norrell, 2009). In Arizona, the U.S. Environmental Protection Agency announced recently that the Cyprus Tohono Corporation has agreed to spend $6 million just to *investigate* contamination from copper mining 30 miles south of Casa Grande (Green Environment, 2009). If American Indian people had degrees as Earth scientists, they could lead these clean-up efforts, instead of depending on the words and deeds of outsiders.

It becomes very apparent from these few cases that the need for American Indian Earth scientists is great. On the other hand, what a closer reading of just these few instances reveals is the likelihood that Earth Science might have a public relations problem with regards to American Indian populations. The article by Norrell (2009) goes on to reveal that Chris Peters of the Seventh Generation Fund believes that uranium mining on indigenous lands is akin to *environmental racism*. He maintains that, if the radioactive waste these mines have produced had

been located elsewhere, the mines would have already been cleaned up. And who is it that *finds* the natural resources to be mined? The Earth scientist.

Another area of study in Earth Sciences is water. Besides the mitigation of pollution caused by uranium and other mining industries, reservation and other tribal lands have water problems that might be remediated by Earth scientists. One area of expertise studied in Earth Science is a method of discovering, through mathematical calculations and a study of subsurface features, what direction in a body of water pollution is coming from, thereby enabling the pinpointing of a source. Earth scientists also use knowledge of what is beneath a landscape's surface to determine where water might be located.

These geological skills could be used by some tribal communities, as the *Tribal Water Plan* from the United States Environmental Protection Agency illustrates (2005). Indian Health Service (2000) data indicates that 71,000 households (includes Alaska Native village households) on tribal lands lack access to basic sanitation, and 31,000 homes on tribal lands lack access to safe drinking water. By 2015, the EPA hopes to reduce the number of households without sanitation and/or access to safe drinking water by 50%. That means that someone is going to have to do this work sometime in the next six years. If there are no Native scientists trained to do the type of work the EPA requires, those jobs will go to people outside the community.

In addition to problems with safe drinking water in households, rivers, lakes, streams, and oceans are home to fish and other wildlife populations which Indigenous people rely upon for food. Some pollutants *bioaccumulate* – they

become stored in the flesh of animals and do not pass from the system, making them unsafe for human consumption. The EPA reports that fish consumption advisories have been issued for 14% of river miles and 28% of lake acres (US EPA, 2005). *Lake acres* are a measure of the surface area of a lake in acres, while *river miles* are a measure of the distance in miles along a river from its mouth.

Shellfish pose a problem to human health as well, as they carry disease causing microorganisms and toxic algae. Tribal community members who practice traditional ways of subsistence fishing are in even more danger of toxic poisoning than recreational fishermen. Of particular problem is mercury, which is commonly spewed into the air by coal-fired utility plants. When Earth scientists from the United States Geological Survey tested fish samples during the period from 1998-2005, they found that *every sample they took* had traces of mercury that were more than 25% above "safe" levels (Williams, 2009). The EPA reports that more than 12 million lake acres and 430 thousand river miles are currently under mercury advisories (US EPA, 2005). Our waters need tending to. Many of them are on American Indian lands. If there are no qualified American Indian scientists to do the job, someone else will be hired.

## Economic Development

### Tribal Self –determination.

American Indian tribes are sovereign nations. As such they seek *self-determination* – the ability to determine for themselves what is best for the tribe. Only tribal nations can determine what their problems are and how to go about finding a solution (NIEA, 2008). Some goals that might be desirable, which could

be expedited by the existence of a trained Native Earth scientist, might include: sustainable industry, energy for electricity, building of homes and infrastructure, environmental mitigation, and education. However, as with students deciding upon a career, it is necessary to have information on a topic before it can be evaluated and subsequently accepted or rejected as an idea. I believe it is possible that many tribes have not considered the benefits of having community members trained to address some of these issues from the position of power that would come from having an advanced degree in Earth Science.

**Jobs.**

The U.S. Bureau of Labor Statistics has reported that there were a total of 266,100 Earth scientist jobs in the United States in 2006. By 2016 that number is expected to increase to 317,446 jobs, an increase of 51,346 jobs. Approximately 1,500 young Earth scientists join the workforce each year (American Geological Institute, 2009). Over the ten-year span (2006-2016), this equals 15,000 new Earth scientists, and represents a shortfall of over 36,000 workers in this field. Native American Earth scientists could fill some of these jobs.

***Job openings.***

The types and numbers of jobs which are projected to become available by 2016 vary by specialization. For example, it is estimated that there will be a need for 12,722 environmental engineers, and 19,157 environmental scientists and specialists in the professional, scientific, and technical services sectors. Architecture and engineering will require 15,781 new workers, and consulting services are expecting an increase of 28,270 jobs. Interestingly, all government

sectors, including federal, state, and local, are expecting a *decrease* in the number of Earth scientists employed (American Geological Institute, 2009).

***Salaries.***

Students graduating with a Bachelor's degree in Earth Science are generally employed in the environmental or hydrology industries. In 2007 they earned an average starting salary of $31,366 per year. Life scientists earned $31,258, and chemistry students earned $32,500 with comparable degrees over the same time period. Students with Master's degrees had the highest starting salaries in the oil and gas industry at an average of $81,300 per year. This industry pays significantly more than the average, which is $46,873 per year. Starting salaries for new Earth Science doctorates averaged $72,600 per year, with 67% of them finding employment in academia (AGI, 2009).

*Table 1* Starting Salaries for New Earth Science Degree Recipients by Industry

| Degree | Industry | Average Salary |
|---|---|---|
| Master's Degree | Oil and Gas | $81,300 |
| | Environmental | $47,500 |
| | Government | $46,200 |
| PhD Degree | Postdoc-Academia | $43,100 |
| | Postdoc-Government | $55,200 |
| | Potentially Permanent-Academia | $51,900 |
| | Private Sector | $72,500 |

***Minorities in Earth Science Jobs.***

The representation of minority populations in Earth Science occupations remains under 10%, with the percentage of American Indian Earth scientists at such a low number that they are unreported in this statistical analysis by the American Geological Institute (Figure 3). Clearly this represents a disparity between the 30.5% of minorities represented in the general population, and those represented by employment in environmental and Earth Science jobs.

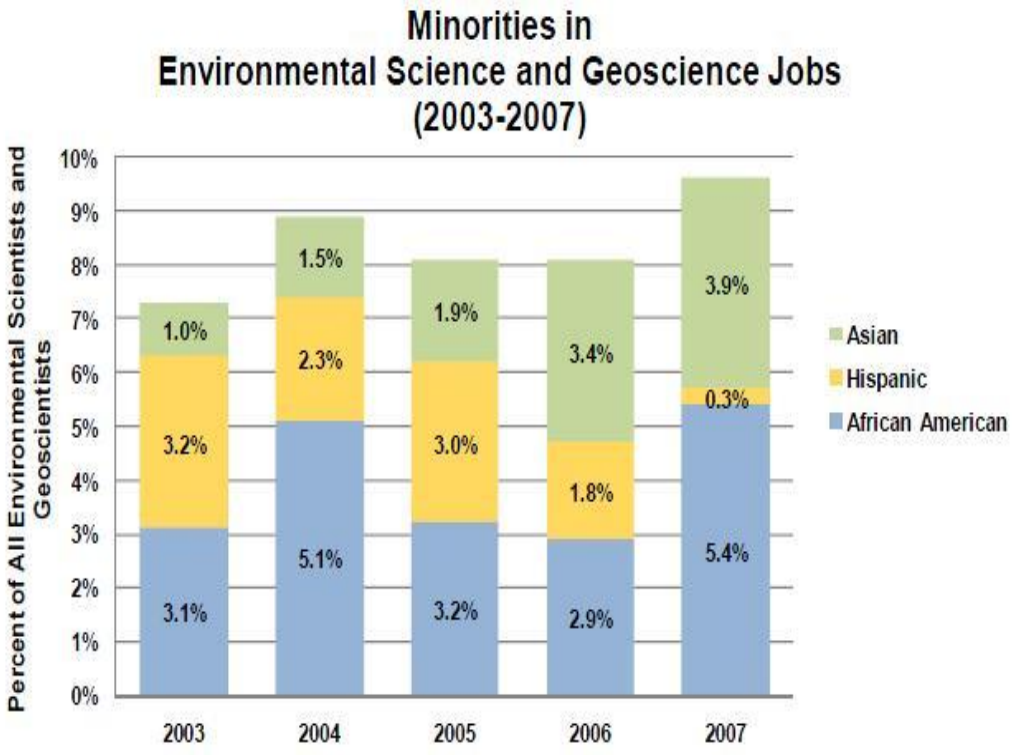



*Figure 3*. Percentage of Minorities in Environmental Science and Earth Science Occupations. Source: AGI Geoscience Workforce Program, data derived from the U.S. Bureau of Labor Statistics

Scientists tend to investigate topics that are of interest to them. These interests are a product of the individual's culture and life experiences. An unfortunate result of this disparity is that when peoples of cultures, such as those of American Indians are not represented in a scientific field, problems that are of relevance to that population tend to fall by the wayside. This is one reason why it is imperative that minority populations begin to increase the number of individuals of minority backgrounds trained and employed in Earth Science fields.

This point was well-illustrated earlier by the instances of environmental racism found on the Navajo and other reservations. And American Indians are not alone. Instances of environmental racism have occurred within other minority segments of the population as well. In fact, the phenomenon of environmental racism is so well documented that the Environmental Protection Agency created an Office of Environmental Justice in 1992 (US EPA, 2010). One obvious solution to the problem of environmental racism is to have members of the community obtain degrees in Earth Science so that they can act from a position of power when communities are threatened.

Another reason for minority communities, particularly the American Indian community, to encourage their youth to pursue an Earth Science degree is the possibility that that young Indian, once trained, will then be able to come back to the community and assist in the economic development of the tribe *as the community sees fit*.

**Education.**

Another well-documented way to increase the economic development within a community is through education. From *The State of Working America 2008/2009,* only 16% of adults who grew up in low-income families but managed to earn a college degree ended up in the bottom fifth of the income scale as adults (Figure 4). Of the adults who started in the bottom fifth of the income scale, 45% remained at that level when they did not obtain a college degree. In other words, among children who grew up in low-income families, those who failed to graduate from college were almost three times more likely to remain in the bottom fifth as adults than those who went on to complete college (Mishel, Bernstein & Shierholz, 2009).

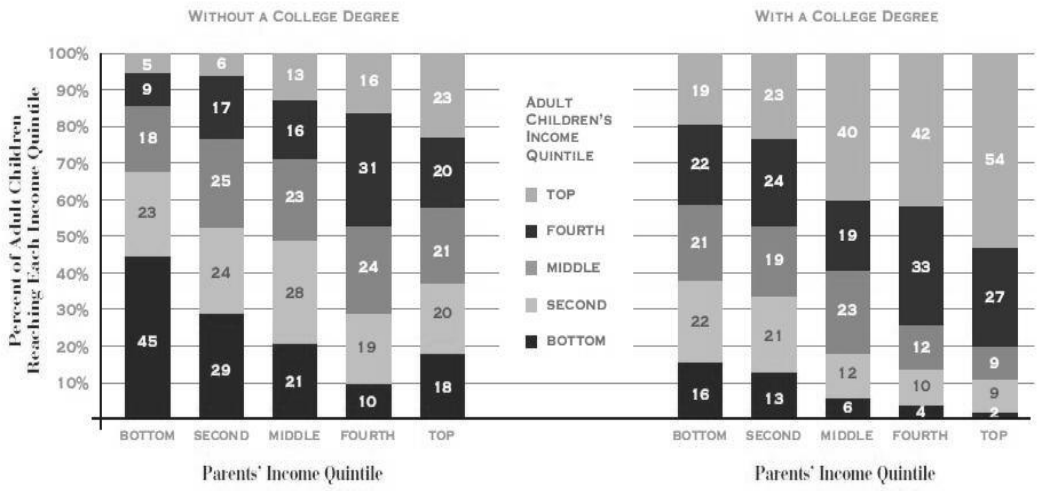



*Figure 4*. Chances of Getting Ahead for Adult Children with and without a College Degree from Families of Varying Income. Source: "Promoting Economic Mobility by Increasing Postsecondary Education," Pew Economic Mobility Project; Haskins, Holzer & Lerman, 2009. pp 10.

Although the economic advantages of obtaining a higher education degree are well-documented, some minority communities may be opposed to having their children leave home to go to college (Diamond, 2010). One of the reasons given in opposition to education is the fear of *brain drain* – the fear that the brightest and, in many ways, most capable members of the community will find lives and jobs away from the community after they have graduated (Bagla, 2002; Commander, Kangasniemi & Winters, 2004).

Another objection, voiced especially by the American Indian community, is the cultural value that children should stay home in their community, and not leave to become educated (Sorensen, 1999). Community members are often afraid that suitable jobs will not exist on the reservation, and children will leave permanently, taking grandchildren with them. As families move further away from their homeland, cultures and ways of life change -- resulting in the loss of both language and cultural practices (Beaulieu, 2000). This situation is being faced by many tribes today.

## Educational Equity

### Minorities in Earth Science.

Compared with other science and engineering fields, the Earth Sciences produce the lowest percentage of minority scientists with Bachelor's and Master's degrees (see Figure 5).

Underrepresented minorities currently comprise 30.5% of the US population, with 15% of the population being non-Hispanic Blacks, 14% Hispanics, and 1.5% American Indian and Alaska Natives. As illustrated in

Figure 6, the percentage of Earth Science Bachelor's degrees conferred on minority students comes nowhere close to 30.5%. In 2004, for example, Hispanics received 3.3% of the BS degrees, Blacks 1.7%, and American Indians0.8%. For Master's degrees in Earth Sciences, the percentages drop to2.3% for Hispanics, 1.4% for Blacks, and 0.5% for American Indians (see Figure 7). At the Doctoral level (Figure 8), in 2004, the rates stayed about the same as for Master's level degrees, with Hispanics garnering 2.3%, Blacks 1.7%, and American Indians 0.4% of the total Earth Science Doctoral degrees conferred (AGI, 2009).

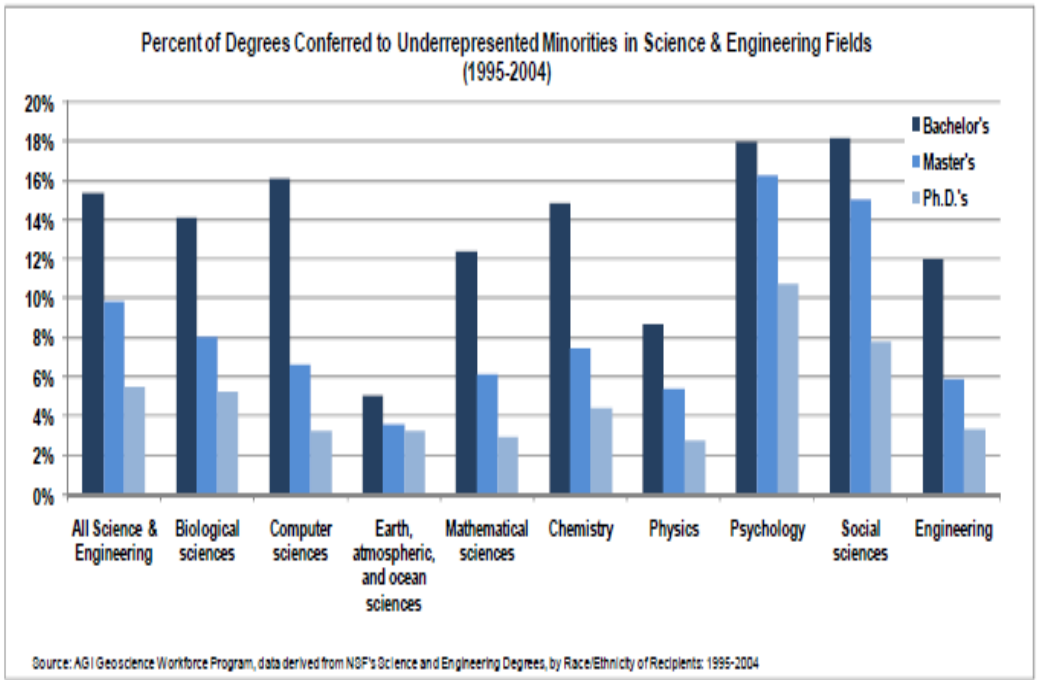



*Figure 5.* Percentage of Degrees Conferred to Minority Students in Science and Engineering Fields. Source: AGI Geoscience Workforce Program, data derived from NSF Science &Engineering Degrees by Race/Ethnicity Recipients: 1995-2004, pp. 33

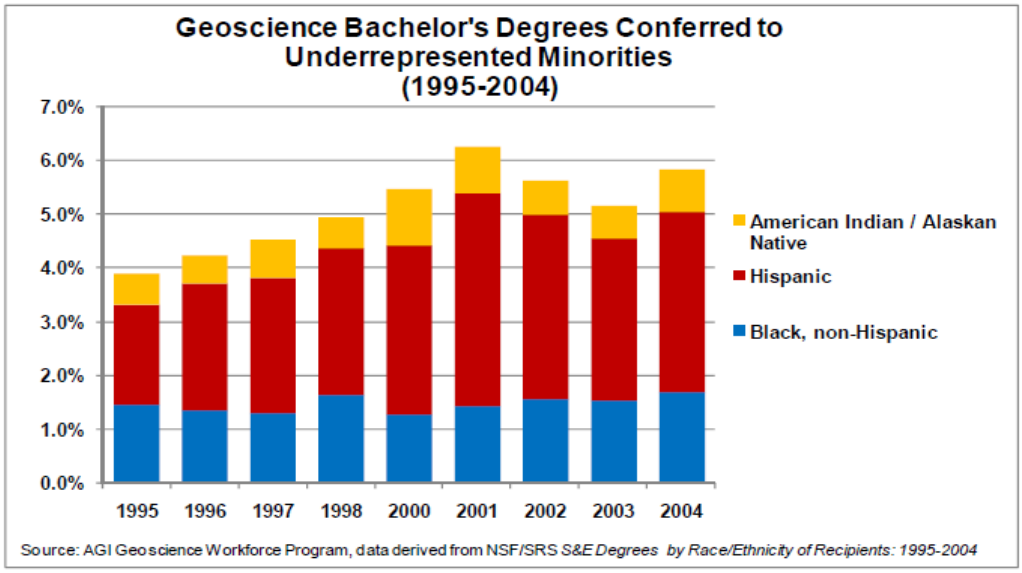



*Figure 6.* Percentage of Earth Science Bachelor's Degrees Conferred to Minority Students. Source: AGI Geoscience Workforce Program, data derived from NSF/SRS S&E Degrees by Race/Ethnicity Recipients: 1995-2004, pp. 33

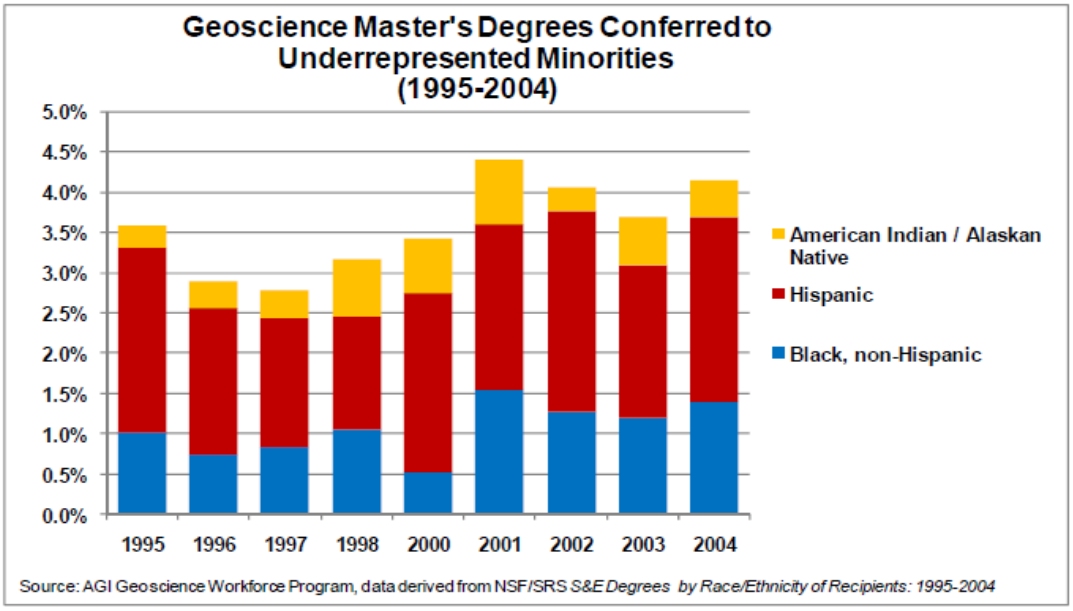



*Figure 7.* Percentage of Earth Science Master's Degrees Conferred to Minority Students. Source: AGI Geoscience Workforce Program, data derived from NSF/SRS S&E Degrees by Race/Ethnicity Recipients: 1995-2004, pp. 33

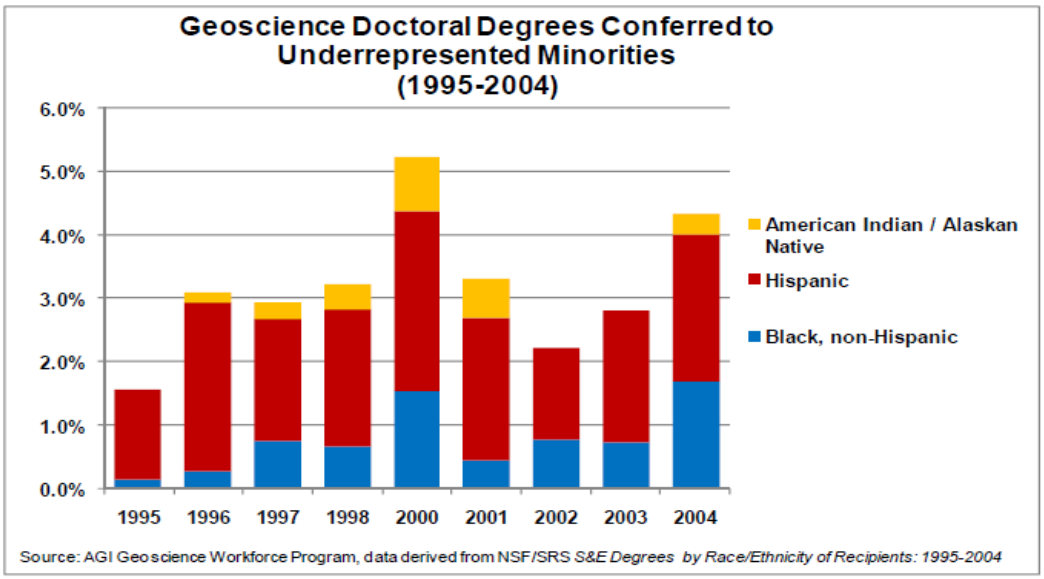



*Figure 8.* Percentage of Earth Science Doctoral Degrees Conferred to Minority Students. Source: AGI Geoscience Workforce Program, data derived from NSF/SRS S&E Degrees by Race/Ethnicity Recipients: 1995-2004, pp. 33.

**Situation, Contribution, Importance.**

My study is situated at the intersection of Earth Science, science education, and equity. First, we have the problem of how to mitigate the effects of climate change and environmental pollution in a way that benefits the people of the Earth. This is an Earth Science issue.

It is an issue from the Science, Technology, and Society realm. I will not be solving this problem with my dissertation. I feel my work will contribute to the solution, however, because it seeks to empower the people who are closest to the land, those who are being most directly affected by these disasters at the present time, by giving them a voice through which science educators might find ways to build pathways for Native American students through Earth science degrees.

Next, we have the problem of not producing enough Earth scientists to meet future demands. The National Science Foundation (NSF) is well aware of the implications of this problem, and has funded numerous programs aimed at finding potential Earth scientists in populations where they do not currently exist. Due to the paucity of minority Earth scientists, minority students are currently being recruited into the field. Yet recruitment efforts are not garnering hordes of hungry minority students wishing to study the Earth Sciences. Summer internships with funding for Native American students often go without applicants.

The problem is so perplexing that NSF has recently funded the *Geoscience Alliance*, a national organization dedicated to Broadening the Participation of Native Americans in the Geosciences. This nation-wide organization is composed of faculty from tribal colleges, universities, and research centers, native elders and community members, industry and corporate representatives, students (K12, undergraduate, and gradute), formal and informal educators, and other interested individuals. I am one of the core foundational members of that group. We are all working towards building pathways for Native Americans to attain advanced degrees in the Earth Sciences.

The third area of intersection is that of equity in science education. There should be no reason, from a purely observational standpoint, why the Earth Sciences, a discipline about the land itself, should produce so few scientists from cultures that know the land and take care to protect it. Yet barriers must exist. I believe that, although minority populations in general are underrepresented in the

Earth Sciences, it is time to dig deeper into this issue to discover why American Indians do not pursue degrees in this science. This study seeks answers to the following research questions.

**Research Questions**

1. Are there factors that impede participation of Native Americans in the Earth Sciences?
2. Are there factors that support participation of Native Americans in the Earth Sciences?
3. In what ways can Earth Science departments strengthen supports and minimize barriers that Native American students encounter when striving to attain a tertiary degree in Earth Science?

**Barriers**

There are many known factors which impede participation in science by underrepresented groups of students. Issues that might prevent a student from pursuing a college degree include lack of income, lack of information, and inadequate educational preparation (Biden, 2009). Minority students are often plagued by added concerns of individual personal barriers and instances of both overt and covert racism within the academy (Castagno and Lee, 2007). Minority students who decide to pursue a degree in science frequently find themselves to be alone within the department, with faculty role models of color either spread thin or non-existent (Good, Halpin & Halpin, 2000; Lee, 2011). This trend seems to be particularly prevalent in the field of Earth Science, where women, as well as

people of color, are still underrepresented at the faculty level (Homes & O'Connell, 2003).

In addition to the lack of scientists of color in academia, a lack of scientists of color exists in the work place as well (Betz, 1994). Coupled with this lack of role models, cultural factors may dictate that minority students resist being assimilated into White culture (McKinley, 2002; Wells, 1989). Minority students may be unable to reconcile their culturally constructed self-image with the identity of a typical Earth scientist (Aikenhead, 1996; Brandt, 2008; Thompson & Windschitl, 2007). Native students have additional barriers different from those of other minority groups (Thomason & Thurber, 1999). Native world views and Indigenous Knowledge Systems are often in direct conflict with the teachings of Western Modern Science (Allen & Crawley, 1998; Dickerson, Neary & Hyche-Johnson, 2000).

## Barriers to a College Education

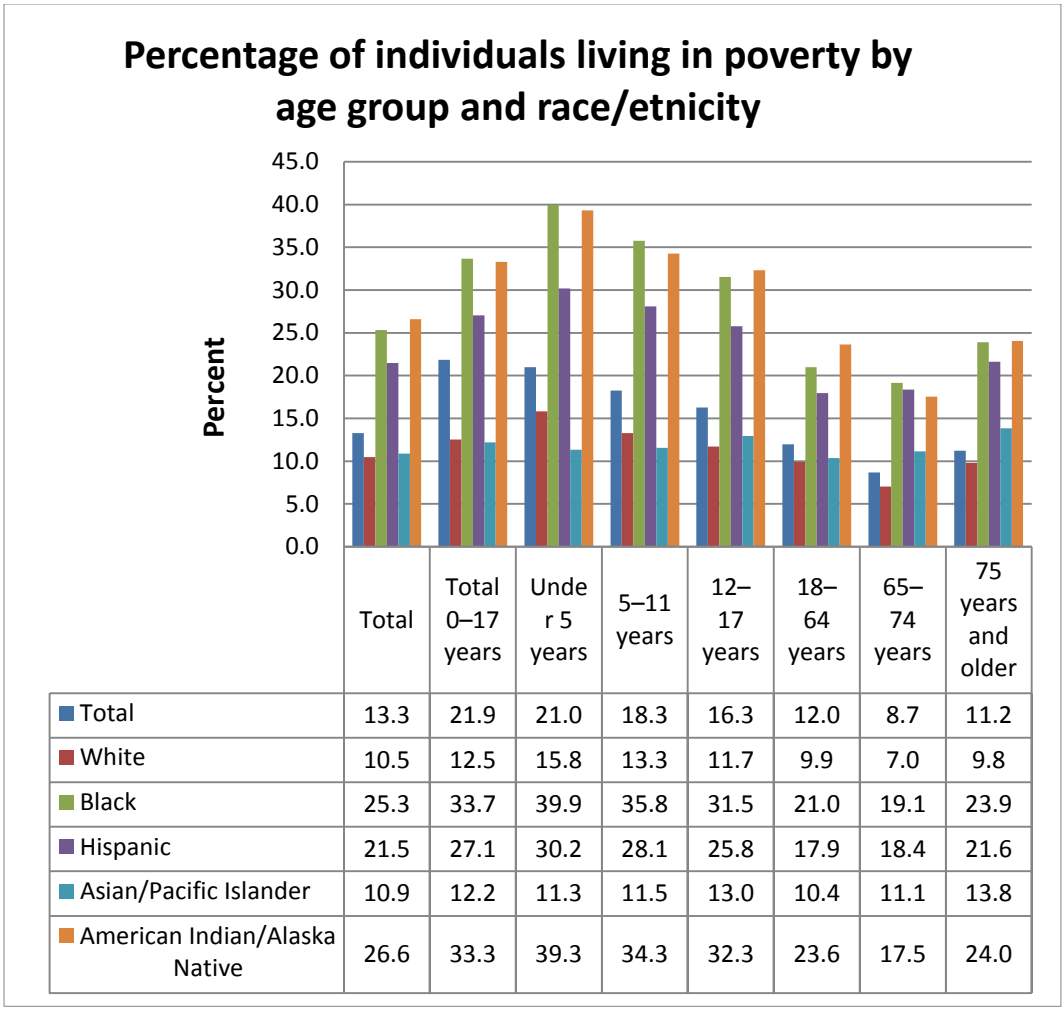
### Income Barriers.

Recently Vice President of the United States Joe Biden headed a task force which explored the barriers to higher education faced by the middle class. This report shows that "family income is a major determinant of college enrollment and especially of college completion. While 78% of high school graduates from high-income families enrolled in college, the shares for middle- and low-income families were 63% and 55%" (Biden, 2009).

According to the US Department of Commerce Census Bureau statistics (2006), there are 4,498,000 American Indian/ Alaska Native people in the United

States. This represents 1.5% of the total US population, with 28.6% (1,286,428 children) of this population under the age of 18. As depicted in Figure 9, the percentage of households containing children with incomes falling below the poverty line is much higher for American Indian, Black, and Hispanic families than it is for White or Asian/Pacific Islander families. For American Indian peoples the problem of poverty is especially magnified on reservations and reservation trust lands, where 47.3% of families lived in poverty in 1989, and 35.7% continued to live in poverty a decade later, in 1999 (see Figure 10). This major determinant of college success, then, puts minority students at a huge disadvantage when compared with their White (and Asian/Pacific Islander) counterparts, and doubly disadvantaged are those Native students who live on reservations.

In addition to problems which are inherent to the condition of poverty, minority students may not pursue a college education even if offered financial aid. Often financial aid is only regarded as aid by minority students if it is in the form of grants, scholarships, or paid work programs. Loans are typically seen as being a financial burden on the family, and insufficient incentive to get an education – a phenomenon known as *loan aversion*. (Heller, 2008; Monks, 2001; Price, 2004).




| | Total | Total 0–17 years | Under 5 years | 5–11 years | 12–17 years | 18–64 years | 65–74 years | 75 years and older |
|---|---|---|---|---|---|---|---|---|
| Total | 13.3 | 21.9 | 21.0 | 18.3 | 16.3 | 12.0 | 8.7 | 11.2 |
| White | 10.5 | 12.5 | 15.8 | 13.3 | 11.7 | 9.9 | 7.0 | 9.8 |
| Black | 25.3 | 33.7 | 39.9 | 35.8 | 31.5 | 21.0 | 19.1 | 23.9 |
| Hispanic | 21.5 | 27.1 | 30.2 | 28.1 | 25.8 | 17.9 | 18.4 | 21.6 |
| Asian/Pacific Islander | 10.9 | 12.2 | 11.3 | 11.5 | 13.0 | 10.4 | 11.1 | 13.8 |
| American Indian/Alaska Native | 26.6 | 33.3 | 39.3 | 34.3 | 32.3 | 23.6 | 17.5 | 24.0 |

*Figure 9.* Percentage of individuals living in poverty by age group and race/ethnicity: 2006. *NOTE: Following the Office of Management and Budget (OMB) Directive 14, the Census Bureau uses a set of money income thresholds that vary by family size and composition to detect who is poor. If the total income for a family or unrelated individual falls below the relevant poverty threshold, then the family or unrelated individual is classified as being "below the poverty level." SOURCE: U.S. Department of Commerce. Census Bureau, American Community Survey, 2006.*

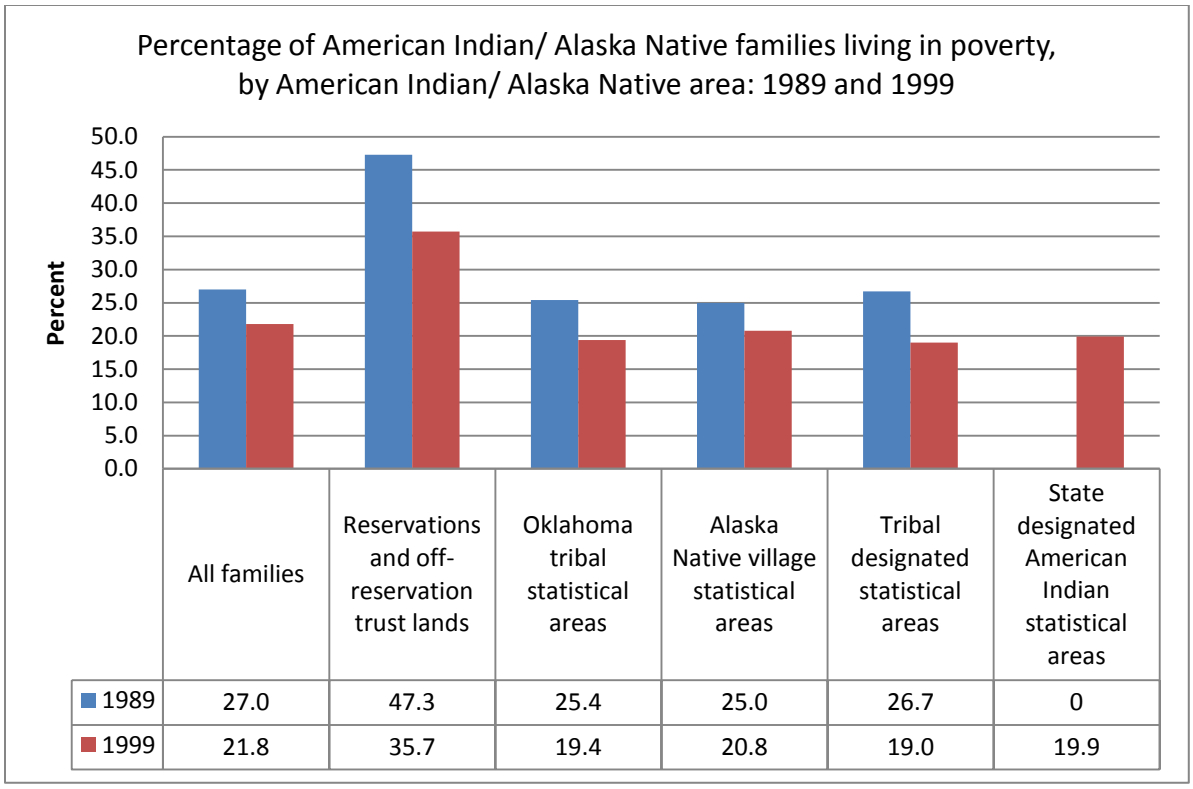



*Figure 10.* Percentage of American Indian / Alaska Native families living in poverty, by American Indian / Alaska Native area: 1989 and 1999.

*NOTE: The Census Bureau divides American Indian/Alaska Native Areas into several categories. Federal American Indian reservations are areas that have been set aside by the United States for the use of tribes, the exterior boundaries of which are defined in the final tribal treaties, agreements, executive orders, federal statutes, secretarial orders, or judicial determinations. State reservations are areas established by individual states for tribes recognized by the state. Off-reservation trust lands (both federal and state) are areas for which the United States holds title in trust for the benefit of a tribe or for an individual Indian. The Census Bureau recognizes and tabulates data for reservations and off-reservation trust lands because American Indian tribes have primary governmental authority*

*over these lands. Oklahoma tribal statistical areas are statistical entities identified and delineated by the Census Bureau in consultation with federally recognized American Indian tribes in Oklahoma that do not currently have a reservation, but once had a reservation in that state. Alaska Native village statistical areas are statistical entities that represent the densely settled portion of Alaska Native villages, which constitute associations, bands, clans, communities, groups, tribes, or villages recognized pursuant to the Alaska Native Claims Settlement Act of 1972. Tribal designated statistical areas are statistical entities identified and delineated for the Census Bureau by federally recognized American Indian tribes that do not currently have a federally recognized land base (reservation or off-reservation trust land). A tribal designated statistical area may not be located in more than one state, and it may not include area within any reservation, off-reservation, Oklahoma tribal, Alaska Native village, or state designated American Indian statistical areas. State designated American Indian statistical areas are entities for state recognized American Indian tribes that do not have a state recognized land base.* SOURCE: Status and Trends in Education of American Indians and Alaska Natives: 2008 (US Department of Ed) pp 27.

**Informational Barriers.**

In addition to income barriers, recent research highlights the presence of information barriers (Biden, 2009). Children from poor or middle-class backgrounds often lack the information necessary to access college. Their informational networks fail to provide them and their families with the information they need to find a good, affordable school along with the financial

aid for which they are eligible. According to Sallie Mae (2009), "low- and middle-income students routinely eliminate colleges from consideration based on cost, before applying for or even researching possible aid packages. In 2009, 50% of students from families with incomes less than $35,000 and 47% of those with family income between $50,000 and $100,000 eliminated colleges based on cost before applying."

In a twelve year study by the Department of Education, it was found that a student's *socioeconomic status* -- a measure calculated through a combination family income, parental education, and occupation -- was just a good a measure of college completion rates as was a student's eighth grade math test performance (Figure 11). As one would expect, students with higher test scores and higher economic status complete college at a higher rate than those with lower test scores and SES. What is surprising, however, is that students with the lowest SES but highest test scores were no more likely to complete college than students with the highest SES but the lowest test scores (Fox, Connolly, & Snyder, 2005).

**Inadequate Educational Preparation Barriers.**

Just as socioeconomic status may prevent a student from reaching their full potential, inadequate scholastic preparation at the high school, and even elementary school, level can dictate a student's career path. For example, inadequate science instruction in both primary and secondary school, particularly for students in low-income or high minority schools, can effectively lock a student out of pursuing a career in science. Gatekeeper math courses such as algebra, if not passed in middle school; tend to track students into lower level

science classes at the secondary level – with the end result that Native and other minority students are often unprepared to consider attempting a science major in college (Gamoran & Hannigan, 2000; Ladson-Billings, 1997).

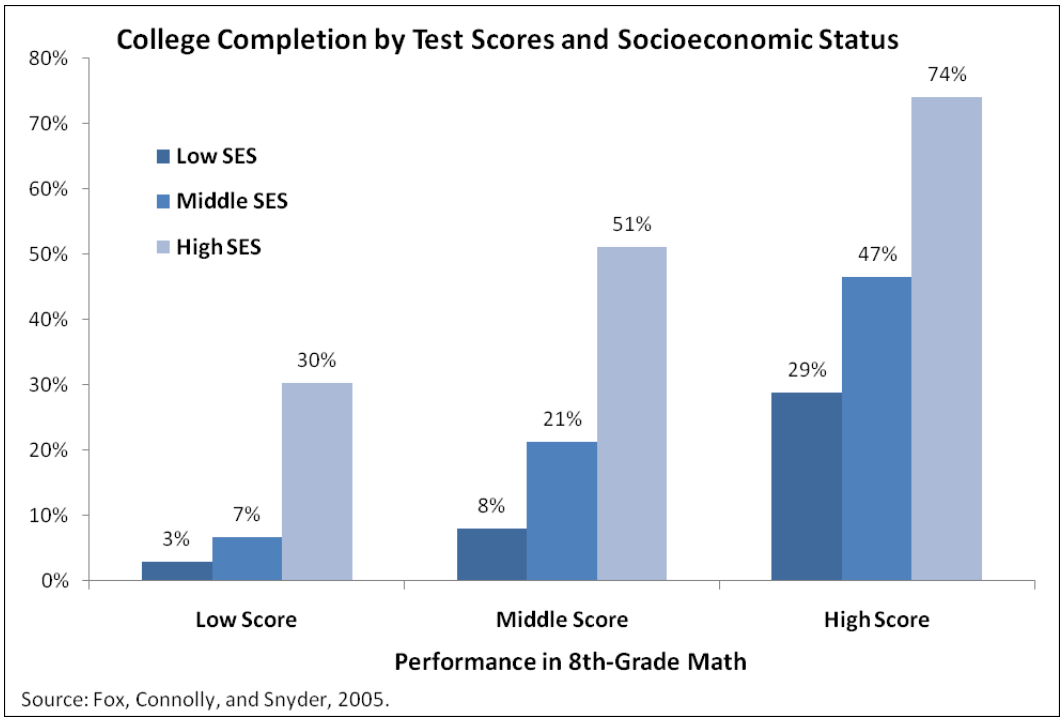



*Figure 11*. Comparison of college completion rates of children based on both their socioeconomic status and their performance on eighth-grade mathematics tests. For both math scores and SES, students are divided into three groups: the "low" group is the bottom quartile, the "middle" group is the middle two quartiles, and the "high" group is the top quartile. Source: White House Task Force on Middle Class Families. (Biden, 2009). pp.7

In addition, Native and other minority students are often steered away from science fields by counselors and teachers at the secondary level. In these all too frequent cases minority students may not have enough *cultural capital* –

academic qualifications, educational experience, cultural dispositions inherited and learned during childhood, embodied characteristics and abilities, and practical cultural competencies – or *social capital* in the form of relatives or family friends who know how to navigate the educational system, to combat the detrimental effects of this advice (Bourdieu, 1986).

Figure 12 shows that while 70% of Native students were at or above basic math achievement levels (as compared to 82% of the total population) in the fourth grade, that percentage dropped to 53% (as compared to 71% of total students) by the eighth grade. Even at 53%, however, basic math skills are generally not good preparation for science, especially Earth Science, which requires students to master two to three courses of Calculus at minimum for a Bachelor of Science degree. The "at or above proficient" level scores indicate that, while 25% of Native students acquired this proficiency at $4^{th}$ grade (as compared to 39% of the total population), only 16% of Native students (as compared to 32% of the total population) scored at or above proficient by the $8^{th}$ grade. Not shown on this chart is the "at advanced" category, that category at which students might be strongly encouraged to pursue a scientific field of study. Only 2% of Native students tested out at this level at $4^{th}$ grade as compared to 6% of the total population, while again 2% of Native students were labeled as advanced in $8^{th}$ grade mathematics as compared to 7% of the total population (US Department of Education, 2008, pp. 79).

While these math proficiency scores do not preclude a career in Earth Science in and of themselves, they do give a good indication that a large

percentage of the total student population, and an even greater population of Native youth, will likely need to engage in math remediation before being prepared to pass calculus at the college level. Aside from any stigma that might be felt by students having to take remedial math classes, the biggest disadvantage of being required to remediate math skills before moving on to required courses might be the extra preparation time (in semesters) needed. And of course, time is money (in the form of tuition and extended time in school), and that circles back to the financial disadvantages of not being properly prepared for college.

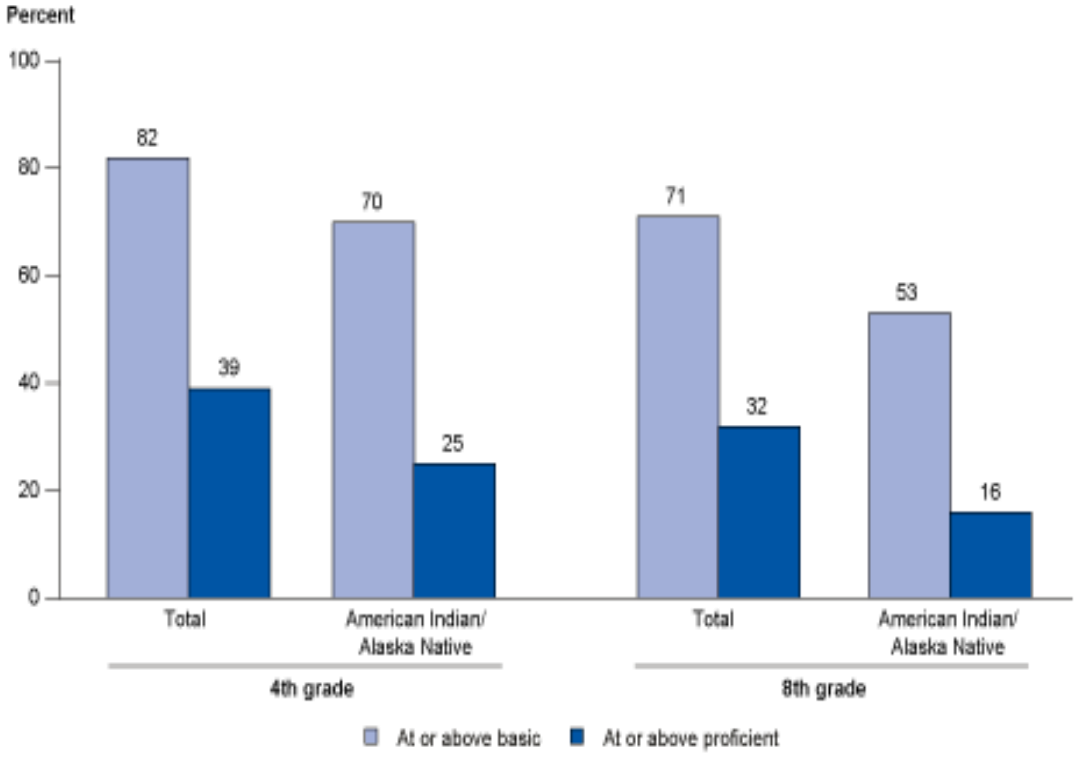



*Figure 12.* Percentage of students at given mathematics achievement levels, by grade and selected race/ethnicity: 2007. SOURCE: Status and Trends in Education of American Indians and Alaska Natives: 2008 (US Dept of Ed) pp 79.

*Table 2. Percentage Distribution of Students across Science Achievement Levels as Measured by the National Assessment of Educational Progress (NAEP), by Race/Ethnicity and Grade: 2005*

| Grade and level | Total[1] | White | Black | Hispanic | Asian Pacific Islander | American Indian Alaska Native |
|---|---|---|---|---|---|---|
| **4th grade** | | | | | | |
| Below basic | 32 | 18 | 62 | 55 | 24 | 48 |
| At or above basic | 68 | 82 | 38 | 45 | 76 | 52 |
| At or above proficient | 29 | 40 | 8 | 11 | 36 | 14 |
| At advanced | 3 | 4 | # | # | 5 | 1 |
| **8th grade** | | | | | | |
| Below basic | 41 | 26 | 72 | 65 | 34 | 66 |
| At or above basic | 59 | 74 | 28 | 35 | 66 | 34 |
| At or above proficient | 29 | 39 | 7 | 10 | 36 | 12 |
| At advanced | 3 | 5 | # | # | 6 | 1 |
| **12th grade** | | | | | | |
| Below basic | 46 | 35 | 81 | 70 | 40 | 52 |
| At or above basic | 54 | 65 | 19 | 30 | 60 | 48 |
| At or above proficient | 18 | 24 | 2 | 5 | 23 | 13 |
| At advanced | 2 | 3 | # | 1 | 3 | # |

# Rounds to zero.
[1]Total includes race/ethnicity categories not separately shown.

NOTE: Scale score ranges from 0 to 300. For a discussion of science achievement levels, please see http://nces.ed.gov/nationsreportcard/science/achieve.asp.

Race categories exclude persons of Hispanic ethnicity.

SOURCE: U.S. Department of Education, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2005 Science Assessment retrieved January 30, 2008, from http://www.nces.ed.gov/nationsreportcard/nde.

In addition to mathematics test scores, the National Assessment of Educational Progress (NAEP) measures science knowledge of earth, physical, and life sciences, as well as scientific inquiry processes and procedures, and the nature of Western Modern science. As shown in Table 2, at the 4th grade level 40% of White students were scored "at or above proficient", compared with 14% of American Indian students, 11% of Hispanic students and 8% of Black students. During the same year, while 39% of White students at the 8th grade level scored "at or above proficient", 12% of American Indian students, 10% of Hispanic students, and 7% of Black students scored at the same level. At the 12th grade level the pattern remains the same, only White students have now dropped to 24% "at or above proficient", while American Indian students remain steady at 13%, Hispanic students numbers decrease by half from 10% to only 5%, and Black students drop more than that -- from 7% to only 2% "at or above proficiency" levels (US Department of Education, 2005). These numbers are a very good indicator of one of the major factors that act as an impediment to creating more scientists in the current educational climate – American students of all races are simply not being prepared to engage in scientific study – even if the interest is there.

## Minorities in College

### Personal Barriers.

Some barriers to minority student success are not erected by institutions, but are rather a product of the culture and community in which they grew up. For example, many poor and low- income youth are expected to find a job and begin

earning money to support the family as soon as possible (Haskins, Holzer & Lerman, 2009, Steele, 1997). Focusing on providing income for a family or oneself takes time and energy away from academic studies, and may lead to higher rates of student failure. In addition, some Black and Hispanic college freshman may suffer from *stereotype vulnerability* – disengagement from school work that stems from fears of living up to the negative stereotypes of minority intellectual inferiority (Massey, Charles, Lundy, and Fischer, 2003). Disengaged students are very likely to fail at least one course during their first semester of college, a portent likely to be frowned upon by science departments.

Many minority students are also *first generation college students* – students who are the first in their family to seek a college education. First-generation status has been shown to have a negative correlation with both students' academic preparation and college persistence rates (U.S. Department of Education, NCES, 2001) These students may face particular strains as family members may not see the need for a college education and provide little emotional or financial support. Role conflicts in balancing the expectations of school, home, and work can take a toll, and parents who do not understand the demands of academic study, particularly in science and engineering fields, may discourage rather than encourage students having academic difficulties (Fernandez, Trenor, Zerda, & Cortes, 2008).

**Racial barriers.**

Dube (1985) described racism as taking three forms: overt, covert, and reactive. *Overt racism* is based on the idea that some races are inherently superior

to others. It is easily identifiable in forms such as attacks by the Ku Klux Klan, racial slurs, and other bodily or verbal violence. It may also take insidious forms such as peppering academic job candidates with barrages of questions designed to infuriate and unnerve them during interviews, while White candidates are treated much differently (De la Luz Reyes & Halcón, 1997). *Covert racism*, racism that is covered or hidden, may be so ingrained in a particular system that it becomes accepted as the status quo. Covert racism tends to be ignored by those who it is not aimed at, and denied by those who contribute to it. In my personal experience it often has manifested itself in a non-majority candidate's research agenda not being in line with the department's goals. *Reactive racism* exists as a reaction to racism by those who have characteristically been the victims – for example a racially motivated act by a black person against a white person as retaliation for racially motivated acts carried out by other whites.

***Overt racism*.**

Many people in the United States today believe that we live in a *colorblind* society – a society in which the color of a person's skin is not seen – and that, therefore, racism does not exist. To the contrary, many examples of overt racism have taken place on college campuses in recent years. As an example, Inside Higher Ed reported, in its article entitled *Racism Rears it Head* (2006), list several examples of incidents that could be perceived as having racial motivations by students of targeted racial groups. In one case, the Sigma Chi fraternity at John Hopkins held a party themed as "Halloween in the Hood". Among the decorations was a plastic skeleton hanging from a rope noose. The

Intelligence Project, an organization which monitors hate groups, reports that college campuses are the third-most popular location for hate crimes in the country.

*Native American mascots and logos.*

Many Native Americans believe that the continued use of Indian mascots and logos to symbolize sports teams is a form of overt racism which still exists today. A case in point is the University of Utah *Utes* – the name of both the university's sports team and the local indigenous Indians of the area. In addition to using the name, the mascot is portrayed as a red-tailed hawk and the community wears paint and feathers to games and routinely do the "tomahawk chop". In one particularly offensive incident during a volleyball game against Brigham Young University in Provo, Utah, a BYU fan wrote racially charged slurs such as "Back to the Rez 4 U" and Trail of Tears Part II" on a white board aimed at the University of Utah team and supporters. Although an apology was later issued, no action was taken against the student by BYU officials ( "Native Student Protest..., 2009).

What is racist about using Native mascots? Apart from stripping Native people of the ability to define themselves in their own image, the Indian team logo or mascot generally plays on stereotypical images of "bloodthirsty savages" while misusing cultural symbols for entertainment purposes (Castagno and Lee, 2007). In addition, the sports team symbolic Indian locks perception of Native people as a culture that existed in the past, impeding Native attempts to redefine their future.

***Covert racism*.**

*Covert Racism and Native American Students in Educational Institutions.*

Covert racism exists at many levels, and is often institutionalized to appear normal. For example, Peggy Wilson's *Trauma of Sioux Indian High School Students* (2009) tells the story of what happens when reservation-schooled Indians are bused to nearby cities for their high school education. When twenty seven teachers were interviewed at the high school, all but one of them claimed that Indian students were not prepared on the reservation for high school. Teachers further stated that since American Indian students did not fit into the system, they had to be placed in vocational or special education classes. Also in these interviews, the teachers said the only time Indian students spoke up was when they were drunk. In this same school, Indian students said that teachers had discretionary powers to enforce attendance policies, and that as soon as Indian students had been absent ten times they were withdrawn from classes, while other (White) students were absent twenty times or more without being withdrawn.

American Indian students often face covert racism at the university level as well. In *Hiding in the Ivy*, Brayboy (2004) describes Native students choosing to make themselves invisible on campus and in classrooms as a way to avoid some of the racism they were subjected to on a daily basis. For example, one student describes being subjected to comments insinuating that she was only admitted to the university because she was Indian, and not because she deserved to be there. A male student described being ostracized because students were intimidated by him (through no action on his part). The feelings became so

overwhelming that the student spent most of his free time in his dorm room. In addition to ostracism, other students often threatened to cut this young man's hair, an overtly racist act.

*Covert Systemic Racism in Admissions Practices.*

Covert systemic racism at the college level often appears as differences in admission rates for minority students. Differences in speech patterns and writing styles may cause a minority student's application to be devalued or rejected if the evaluator comes from a different culture (Thomason & Thurber, 1999). This issue tends to be exacerbated at the graduate level, where admissions decisions are often made by faculty members, the majority of whom are White.

## Minorities in Science

### Lack of Role Models.

Western Modern Science is still widely perceived to be the domain of white men, therefore, women and minorities often do not see themselves as scientists, and do not pursue studies in scientific fields. The lack of role models which physically resemble students is seen as having an alienating effect on minority participation in science (Pollard, Jagger, Perryman, Van Gent & Mann, 2004).

### Identity Barriers.

Identity is a way of thinking and being in the world. Identities are fundamental to learning and participating in a classroom, and are linked to issues of power, privilege, and access (Steele, 1997; Ogbu, 1989; Fordham, 1988). When students' identities are not in line with the identities traditionally promoted

in the science classroom, students are less likely to have opportunities to participate in classroom activities and discourse (Thompson & Windschitl, 2007). Typically, only limited views of scientific identities are portrayed in classrooms, contributing to the problem (Atwater, 2000).

Rigid science performance standards often require students to assimilate and change who they are as a person in order to be successful in an academic program. Some minority youth believe that if they identify with White culture and ways of being successful, they might lose their own cultural identity, sense of community, and self-worth. In one example, Ogbu and Fordham (1986) describe how an African American student felt she had to fit in to a high-achieving school by "acting White" and not "being loud".

In the case of American Indian students, tendencies of Western science classrooms to require individualistic academic achievement efforts, rather than promoting cooperative learning, may be in direct conflict with cultural values of cooperation. Standard Western scientific identities that are stereotypically masculine, coupled with the tendency of males to dominate discourse and commandeer materials during hands-on investigations, also do not mesh with traditional Native roles in which women are often family and clan leaders (Almeida, 1997; Deyhle & Margonis, 1995; Tobin, 1996).

## American Indians in Earth Science

### Native science and Western science.

Just as Native peoples are suspicious of Western Modern scientists, Western Modern scientists are suspicious of those things that are *known*

seemingly without "proper", rigorous testing. One of the barriers for Native students, then, is that Western Modern scientists often do not recognize Native Knowledge as being *scientific*, and therefore, devalue it as being inconsequential.

Native science students faced with attempting to reconcile what they *know* from their training within their culture, with what they are being taught in Western Modern science classrooms are often faced with the difficult task of *border crossing* – shifting between cultures or sub-cultures (Aikenhead, 1996). Western Modern science is itself a sub-culture of Western European thought. It was institutionalized in the 17$^{th}$ century as a predominantly White, male, middle-class, Western system of meaning and symbols (Simonelli, 1994). As such, many students have difficulties negotiating the border crossing into the scientific world. The problem seems exacerbated, however, when race, socio-economic class, and worldview are all incongruent with the sub-culture of science, as is the case with many Native students.

Border-crossing takes two main paths. If a student's life-world culture is generally compatible with the sub-culture of science, then science instruction will tend to support the student's *worldview* (culturally validated presuppositions about the natural world), a process known as *enculturation*. If, on the other hand, a student's life-world culture is generally incompatible with the subculture of science, science instruction will tend to disrupt the student's worldview by trying to replace it or marginalize it in a process known as *assimilation* (Aikenhead, 1996). Costa (1995) found that border-crossing into the subculture of science can

be smooth, manageable, hazardous, or virtually impossible, depending on the student's life-culture and worldview.

Learning science also involves learning specialized academic language. This language acquisition becomes particularly problematic for some Native students when Native languages are spoken in the home or community. Scientific terms may have no equivalent word, or possibly even concept, in the Native tongue (Brayboy & Castagno, 2008).

**Supports**

Given all the barriers that Native students face, there are some things that might work to support student progress. The foremost of these is financial support (Beaulieu, 1991). Without financial support in the form of grants, scholarships, and work programs, students from low socio-economic status may find the pressures of education and work overwhelming. In addition to financial support, Native students have a need for academic counseling from practitioners sympathetic to the unique problems that Native students face (Dolence, 1991).

A very striking need is that for adequate mathematics and science education at both the elementary and secondary levels. Coupled with the need for science and math education, the curriculum should be *culturally responsive* – it should integrate Native and Western knowledge systems while enhancing the cultural well being, science skills, and knowledge of Native students (Brayboy & Castagno, 2009; Stephens, 2000). At the tertiary level, Native students often will need tutoring services to get them through higher level math courses such as calculus if they are to be successful in securing an Earth Science degree.

Native students also need a safe haven from the effects of racism. Cultural Centers on campus, such as the Native American Longhouse found at Oregon State University, can also serve to combat the sense of loneliness and isolation felt by many Native students, providing a substitute family and community support network.

In the absence of Native role models, mentoring becomes particularly important. Some retention studies have suggested that American Indian students should be assigned mentors whose responsibility it then becomes to keep contact with the student (Thomason & Thurber, 1999). Other ideas to promote faculty-student interaction include scheduling orientation sessions presented by faculty, and individual faculty-student appointments to encourage the asking of questions (Dickerson, Neary, & Hyche-Johnson, 2000; Courage & Godbey, 1992).

One way that teachers and faculty members can assist students in making cultural border-crossings is to explicitly tell students when these border crossings are being made. For example, Aikenhead (1996) suggests that students be instructed to divide their notebook paper in half and write “my idea” over the left-hand column and “subculture of science” over the right-hand column. Students should then write how they view a phenomenon under one heading, and the Western Modern scientific explanation in the other column. The idea is that students will then be explicitly able to see where the borders are, and crossing will be facilitated. I must admit I have never seen this done in practice, however.

One of the biggest supports for Native student success seems to come from the community itself. Native students are often tied strongly to their family

and community, and approval from elders and family members is intrinsically necessary to many Native students' success. The American Indian Graduate Center publishes a pamphlet for Native high school students considering a college degree. Along with information on college vocabulary, entrance exam testing, and student aid, the guide provides "Tips for Native Youth", "Tips from Native Elders", and "Tips for Native Parents". Foremost among all three sections of tips is an admonishment to seek the advice of and listen to Native Elders, participate in cultural activities, and serve as a role model and mentor to others (American Indian Graduate Center, 2005).

## Chapter 3

# Methodology

## Theoretical Framework

### Postcolonial Theory

*Postcolonial theory* provides a framework that destabilizes Western *epistemologies* – ways of knowing -- thereby creating spaces for other epistemologies. Sometimes the theory is taken to mean, literally, the *time period after colonization*. This is not the case, particularly when discussing issues related to American Indian people. However, when looking at *education* and American Indian *students*, we must remember that the current educational system is one that is not naturally occurring in the culture, but rather was *imposed* on Native people by the United States Government *after treaties had been signed between the two governments*. This makes the United States, in relationship to Native peoples, the *colonizer* and the indigenous peoples the *colonized*. In this way the United States *is* a colonial society. Postcolonial Theory challenges assumptions in Western society, particularly as they relate to different places, peoples, and cultures.

Postcolonial Theory deals particularly well with cultural identity, the ways in which knowledge is generated, and the ways in which indigenous knowledge is subordinated by the dominant society. Embedded in the theory is the idea of *essentialism* – that groups can be boiled down to essential characteristics. For example: Are we essentially White? Are we essentially Native? Spivak (1988) posited that, while essentialism runs the risk of creating stereotypes of peoples of a particular culture, it is often useful to produce a clear identity which can be

accepted by the majority when engaging in postcolonial work. McKinley (2007) ascertains that, while essentialism blurs the boundaries of differences among peoples, she uses the term *indigenous* "to form a collective of people who share some similarities in their aspirations and circumstances." (p.203)

McKinley advocates use of Postcolonial Theory "to affect a more complex picture of colonizing history and politics and its influence on science education research for indigenous students" (p.201). Since I am studying indigenous students and their pathways to obtaining an Earth Science degree, Postcolonial Theory is a proper theoretical framework from which to proceed. Postcolonial Theory allows me to get at any institutionalized structures that are in place which reflect a Western perspective, demonstrate that they exist, and show how they affect indigenous students. In this case, I look for institutional barriers within the structure of Earth Science education which hamper or prevent Native students from attaining degrees in this field.

**Socio-cultural Perspective and Critical Tradition**

The *cultural perspective* recognizes that teaching science is an attempt at transmitting a scientific sub-culture to students (Hawkins and Pea, 1987). The *socio-cultural perspective* recognizes that attempt as happening when participating in activities with other people. The socio-cultural approach is particularly important to American Indian students' learning, as much of Indigenous Knowledge (IK) is gained through experiential activity with other members of the community. In this way, a socio-cultural research perspective

with an ethnographic approach is suitable for studying how IK interacts with Earth Science education.

However, this research project also involves aspects of the *critical tradition*. The critical tradition recognizes that students' difficulties in learning science are due to hidden conceptual or cultural conflicts, but is concerned with the way these conflicts are controlled by power structures and ideology within the dominant society. My research blends both the socio-cultural and critical perspectives because I believe that science knowledge is socially and culturally constructed, but that the educational system decides what knowledge is to be constructed and considered *science*. Since knowledge is power, those who decide what counts as knowledge hold the power. The purpose of this work is to worry the boundaries of that knowledge to make room for the Indigenous Knowledge perspective in the Earth Sciences, thereby increasing the collective power of Native peoples.

**My Position**

Within the tradition of *postcolonial theory*, my strategic location – my position with regards to the material I write about here – is that of a *migrant writer*. By this I mean that I have not lived my life in any one particular place, nor am I embedded in any one particular culture. I am not Native American, but neither am I White. I have studied in two different Earth Science departments, earning both Bachelor's and Master's degrees in geoscience. But I have also worked in public education for many years with diverse learners, and I am completing my PhD in Science Education. I am also a non-traditional, first

generation college student and a woman. It is in this way that I see myself as uniquely qualified to negotiate the intersecting spheres of science education, Earth Science, and the American Indian student. It is from this perspective that I will do my work.

## Research Methods

### Data Gathering Methods

I am on the Board of Directors of the *Geoscience Alliance,* a national organization interested in broadening the participation of Native Americans in the Earth Sciences. Through a National Science Foundation grant, we were able to come together for an initial meeting October 28-29, 2009. At this meeting we discussed my dissertation, and the members agreed that the organization should support my efforts at completing it. With this goal in mind, the first session at our initial conference, which took place September 16-19, 2010 in Cloquet, Minnesota, was a round-table discussion of the topic of my dissertation held simultaneously in four separate break-out rooms. Approximately 100 members took part in these in-depth discussions. Signed permissions to tape were gathered from each participant at conference check-in. The sessions were taped and later transcribed. The information garnered at these sessions was used to hone my semi-structured interview questions.

At the Geoscience Alliance conference I was introduced to many American Indian and Alaska Native Earth scientists. During the conference I was asked to explain my dissertation topic to the group. At that time I also invited everyone present to participate in my study. As the conference proceeded I was

able to tape some of the participants there and set up interviews with others for some time in the future. Two weeks later I attended the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS) conference. At the SACNAS conference I was invited to speak at a Geoscience Alliance session where we talked about the conference and my dissertation. As the SACNAS conference progressed I was able to garner names and promises for interviews from more Native Earth scientists.

Through the contacts I made with the help of members of both of these organizations, I put together a list of potential participants for my study. I contacted everyone on the list of potential participants and ended up with 20 responses. I interviewed 20 people in total, with 15 of the participants being Native Earth scientists. The other five participants were non-Native directors of programs which were designed to recruit and mentor American Indian students in the Earth Sciences. Additionally five of the Native Earth scientists also were program directors. This sub-set of interviewees was shaped by their participation in the Geoscience Alliance and/or SACNAS organizations as well as their willingness to participate in this study.

Interview questions were tailored for the participant. For example, a Native Earth scientist who was also a program director was asked all the questions that a Native student was asked, but had an additional set of questions which pertained to their programs. Questions were altered slightly as the interviews proceeded, but the basic structures of the question sets remained intact for all participants. Data collection was completed at the end of November, 2010.

All data was transcribed by the author, and was completed by the end of December, 2010.

Interview surveys were conducted orally, with the interviewer asking questions of the participant. Interview surveys were conducted either face-to-face or over the phone. The interview survey questions I used were semi-structured. With a *semi-structured interview*, all the questions are asked in the same way and the same order, but the interviewer often probes for additional information from the responses received. I chose to use an interview survey approach because it provided for increased contact with the participants and allowed participants to ask questions and talk freely.

I used the semi-structured interview format because it gave me an initial framework for analysis – with the primary unit of analysis being the question – while still allowing me to probe for additional details. Probing for details was important in this study because I felt that there were possibly unexpected barriers facing Native students that a structured interview would fail to reveal. I also used a brief close-ended survey for demographic data as part of my data gathering process.

**Data Analysis Methods**

Using the principles set forth by Miles and Huberman (1984) I did a qualitative analysis of the interview survey data. First I read the entire corpus of data twice. While I read I made notes in the margins of interesting points brought out in the data. Then I began to get a sense of who the participants were and their life pathways by analyzing the questions about the participants' educational

backgrounds on a question by question basis. For example, I took all the participants' answers to the question, *What was your elementary school like?*, and cut and pasted them into one continuous document. Then I coded and analyzed this one question until I got a clear picture of their elementary school experience. I did the same with the high school and college pathway data. After this I realized that I needed to look at the connections between their school experiences and their individual pathways, so I drew a representation of their life pathways which included such things as the number of elementary schools they attended, whether there were any gaps in schooling, etc. I have decided not to publish these maps because; although informative and interesting, they might reveal the identity of my participants. I have stripped away as much identifying information as possible when writing this document because the total sample of Native American Earth scientists is so small that including even a small amount of details may cause the participants to be recognized. I have, however, written participant descriptions of the Native Earth scientists using pseudonyms. These descriptions were sent to participants for review and approval before publishing this work.

After writing the *Demographics* section of the *Results*, I then proceeded to code for the *Barriers* to student success. Qualitative data analysis is an iterative process; one pass through the data is not enough to extract all the information the data can provide, and coding categories are in a state of flux as the coding proceeds. Categories were constantly checked using constant comparison analysis. *Constant comparison analysis* refers to checking each piece of data to

make sure that it fits both categories and connections which are emerging – if a piece of data does not fit, either categories or connections need to be altered.

As each new code became revealed I went back and combed each interview for examples of its occurrence throughout the interviews. As I worked with the data I began by having many different categories of barriers and then consolidating the information into fewer categories with common themes. As I wrote the results for each category I combed the data again to make sure that all instances of each category had been found. At this time I also looked for disavowing examples. The same procedure was followed when analyzing for *Supports*.

## Chapter 4

# Data Analysis and Results

## Participant Descriptions

Twenty people participated in in-depth interviews. The interviews ranged from 28 minutes to 72 minutes in length, with most lasting in the range of 60 minutes. Of the twenty people, 15 were of Native American or Alaska Native heritage, while five were not. The five participants who were not Native were all program directors who work directly with Native American students. The participant descriptions reported here are of the Native participants only. Brief descriptions for each participant follow.

### Angela

Angela went to several different elementary schools. First through fourth grade she attended elementary school in a small city while her mother pursued a BS degree. Her family then moved back to their tribal community, where she attended two different very small schools. In the larger of the two communities, the total population was about 200, and the teacher taught K-12 all at once. The curriculum consisted of mainly rote memorization and drill and practice. When she was in 6$^{th}$ and 7$^{th}$ grade, she was exposed to high school "physics, geology, natural earth processes and biology", which she felt helped her later to get into Advanced Placement classes. When she was in the 8$^{th}$ grade her family moved to a larger city, where graduated from high school in the 2000s. Her mother and high school advisors steered her in the direction of college, which she pursued out of state. Angela recently received her BS in Earth Science.

**Barbara**

Barbara grew up on her reservation, and attended tribal elementary school there. Her elementary school population was 99% Native. In elementary school, according to Barbara, "we didn't really do that much in class. We weren't being introduced to any math, science, or other types of discipline." When she was twelve, her parents decided that their children needed a better high school education than that available on the reservation and moved the family.

Barbara attended middle and high school in a border town, and she reported a huge culture shock in the transition. She said "in every high school there are clicks or groups that people separate into and I wasn't really used to that." When Barbara first enrolled in her new school her name did not appear on her English teacher's register, so she went back to her homeroom. Her homeroom teacher just happened to teach an Honors English class that period and she was allowed to stay, which lead to registration in other Honors and Advanced Placement classes later. During her high school summer months she attended eight-week long high school summer immersion programs thousands of miles from home every year for four years. This program drew international students and exposed Barbara to many advanced subjects, including pre-Calculus. Barbara graduated from high school in the late 2000s.

Barbara's parents expected her to go to college, but originally wanted her to pursue a medical degree. Since she wasn't sure what field she wanted to major in, Barbara opted to enroll in a nearby college rather than attend more expensive out-of-state universities, even though they had offered scholarships. Barbara

credits her high school Earth Science class with developing her interest in Earth Science, but her college introductory geology professor with turning that interest into a passion. Barbara has completed a BS degree in Earth Science.

**Cindy**

Cindy moved a great deal during her childhood due to her father's pursuit of work. She lived nationally, internationally, and on tribal lands. Her elementary school experiences included a Catholic school, school for international dignitaries, Montessori school, and a suburban public school, where she was placed with the problem kids due to space constraints. In middle school she was identified as gifted and placed in Honors classes except for mathematics. She graduated from high school in the early 1980s. She was coerced by her father to enroll in college in exchange for free room and board (as opposed to pursing a cosmetology license), and subsequently enrolled in a community college. Both her parents went to college while she was a student, and achieved Bachelor's degrees.

After completing her general education requirements, Cindy enrolled in a university, choosing her Earth Science major by reading class descriptions from the course catalog. Lack of support from professors in her sub-field of choice lead her to switch emphasis areas, a move which brought her into contact with an inspirational female mentor, who guided her through her undergraduate years to the completion of a BS degree in Earth Science. Although Cindy was offered a full-ride doctoral scholarship at a prestigious university, she opted for an MS program which offered training in practical problem-solving of environmental

issues. After completing her MS degree, Cindy now works for a governmental science agency. She is a single mother and no longer engages in research due to a job shift towards science communication.

**Deborah**

Deborah is an artist who moved extensively during childhood and was home schooled for much of the time. She was also prone to long bouts of illness. Although dropping out of high school "was not an option" she didn't take any college prep courses, focusing instead on art classes, vocational education, and "just getting through". She did not enroll in algebra or any other upper level math courses, and took anatomy for science to help with her drawing skills. Deborah graduated from high school in the late 1990s.

After high school Deborah realized that she didn't have the skills to get a good job, so she enrolled in a nearby community college "hoping something would present itself as a viable career option". She is a first-generation college student. Deborah credits her introductory geology professor, and a geology trip to Iceland, with sparking her love for Earth Science. Although she did not have a background in mathematics, she found that studying math for the purpose of learning Earth Science made it both tolerable and understandable. After earning an AA in general education, Deborah has since earned a BS and MS Earth Science, and is currently completing her PhD.

**Erin**

Erin's family had roots in two different states separated by 1000's of miles. One was in a small town setting far from the reservation, the other in her

ancestral homeland. Her elementary school years found her first in the small town, then in her homeland for the later elementary and middle school years. For high school she was back in the small town. Erin "found science learning the subsistence fishing and gathering of berries and playing in the woods all the time". When Erin was in high school, her guidance counselors refused to put her in college prep classes, insisting instead that she would be a factory worker and needed vocational education. As a result she graduated from high school in the early 1990s having only taken "Biology as a senior and pre-algebra". Still wanting to go to college, Erin spent her first semester at a tribal college, then moved nearer to her family and continued on with community college. She is a first generation college student.

Erin got married, had children, and worked as she obtained her AA degree, a process which took over six years. She then enrolled in a university intent on a medical degree. However, volunteering in an environmental science lab set her on her current path. Erin now has a BS in Biology, a BS in Geology, and is currently working on her MS in Earth Science.

**Flora**

Flora "was raised totally white". Her elementary school and high school classmates were all "whitey tighty", and she "could always pass" for white. She never revealed that she was Native. In high school she took all college prep classes and fell in love with biology. She hated math and chemistry – because it had math in it. Flora graduated from high school in the early 1970s. Her parents always spoke to her as if she would go to college even though they were not

college graduates themselves, and she describes herself as being “the poster child for getting into good schools”.

Flora credits the time she spent playing outdoors as being instrumental in developing her love for the environment and Earth. She really liked science, but felt trapped in female roles. Her parents wanted her to be a teacher, but she chose nursing because of her love for biology. She soon discovered that was not what she wanted to do, and switched majors to psychology. She was married and having children while pursuing her studies. After a family tragedy occurred, she quit school.

During the next three decades she raised a large family while working on the land. After nearly thirty years she returned to school and finished her undergraduate degree. While an undergraduate she did an internship in environmental education, and realized she was now free to pursue her passion of studying the Earth. She then worked while completing an MS degree in Earth Science. After completing her MS degree, Flora became a faculty member at a tribal college, but realized she was not finished with her education. Flora is currently working toward a PhD.

**Geneva**

Geneva never lived on a reservation. Starting in the fourth grade she attended a private, religious school until she graduated from high school in the late 1970s. She did not receive a good foundation in science, and her math skills were poor. Geneva is a first generation student whose parents expected her to go to college. She began her college pathway in a religious institution, but soon

became disillusioned with the segregation of roles and curriculum for men and women. She subsequently dropped out and began to work full time.

As Geneva worked she realized that she was not prepared to support herself, so she decided to go back to school to pursue an AA degree in art. After achieving the degree and working for over ten years, Geneva began to feel something was missing from her life, that she "wanted to make a difference" in the lives of her people, and that she had a responsibility as an Indian person to take care of the Earth. As she helplessly watched the events after Hurricane Katrina unfold, she realized she wanted to fight environmental injustice, but she needed to overcome her fear of math. So she took a math course at the local community college and realized that somehow she had developed the skills she needed to succeed in mathematics through her work. She quit her job, sold her possessions, and enrolled in a university several hundred miles away. She is currently completing a BS degree in Earth Science.

**Hope**

Hope grew up in a large family in a city near her reservation. Her father earned a certificate beyond high school, and her mother tried to get a college degree but dropped out due to her difficulties with math and chemistry. Hope is a first generation college student. Hope described her mother as "always involved with Indian education". Hope's mother pushed her to attend summer science programs as a teenager, a fact that Hope said is the "reason why I am still in school". Hope grew up playing in the outdoors and loving it.

Hope described her public elementary school as being “good” and “mostly white”. She had a principal who “ran it like a military school” and was “really strict”. In high school she was very athletic, but had friends who were artists, musicians, and skateboarders. She liked science and took advanced classes, but only took the bare minimum of classes in math. She graduated from high school in the late 1990s. After taking a year off from school to work full time, Hope enrolled in a tribal college, where she earned an AS degree. She is currently working on her BS degree in Earth Science.

**Indigo**

Indigo was raised traditionally on her reservation. As the eldest child, she often worked alongside her father in the fields. She attended a one room school house near her home until seventh grade. The curriculum was interdisciplinary and taught by a retired geologist. Many of the lessons took place outdoors. She only had one other student in her grade, her cousin, from Kindergarten through seventh grade. In the eighth grade she transferred to a public school in a nearby border town, where she found a hundred students in her grade level. Although able to do the coursework, dealing with her peers socially was a challenge as she was very shy. Math classes also presented a problem, and she received tutoring from her grandmother every day to pass them. She did well in science. Indigo graduated from high school in the late 1980s.

Indigo is a first generation college student. After high school, her parents decided that she would go to college and enrolled her in the nearest university. They even filled out all the paperwork for her. When they drove her to the

university and dropped her off at her dorm she had never spent a night away from her parents. Culture shock was so severe that she did not leave her dorm room floor for nearly two weeks. After being coaxed out by a woman from student services, a chance meeting with an administrator provided her with a mentor who guided her through her college years.

Indigo obtained a BS in a human services related field, but quickly realized she wanted to help her people by teaching them "about science, about culture, about our place, where we are from". She subsequently earned a Master's degree and then a PhD in Earth Science. Indigo is currently a faculty member at a university.

**Kathy**

Kathy grew up in a small city with a relatively large Native population. From the first through fifth grade she lived in an area with high ethnic diversity, which was reflected in the school. In sixth grade she moved to a school where "me and one other family were the only minorities of any kind". She reported that she could really feel the difference and that some of the teachers were "really very strongly prejudiced." Kathy enjoyed school. In high school Kathy did very well in both English and math. She took algebra II with trigonometry in the ninth grade, but no one recommended that she take more math, so she took the minimum required. Kathy graduated from high school in the 1970s.

Kathy is a first generation college student. She knew as a senior in high school that she wanted to work with the land, but did not know what that meant or how to prepare for a career in Earth Science, so she interviewed workers at

various agencies to garner information on careers and college. She took the advice of one of her interviewees and enrolled in a university thousands of miles from home. Once there, she was inundated with culture shock, found a lot of prejudice there, and returned home after one year. She completed her second year at a university near her home, but decided she would not complete her education there because the university did not offer the type of degree she was interested in. She spent the year researching other universities by microfiche in the library and settled on a university many miles away with promising programs and a high percentage of Native students. She loved it there and completed her BS in Earth Science. After working in a governmental science agency for many years she is now teaches Earth Science from a tribal leadership perspective to rural community members.

**Linda**

Linda grew up in the suburb of a large city and attended public school. She describes her elementary school as being "very white and very big" with five or six teachers per grade. She also attended a very large, public high school at which she "did not know anyone else who had Native American background". She enrolled in both Honors and Advanced Placement courses and felt very prepared for college. She graduated from high school in the 1980s.

Linda's father had obtained a BS through his GI Bill benefits, and Linda was expected to go to college. She attended a college two hours away from her home, which was also the college of choice for many of her high school friends. She received a BS in Mathematics and then worked in industry for over ten years. Her

employer sent her back to school to obtain a Master's degree, but as she prepared to enter her first class she saw a sign on the wall advertising a program which would allow her to follow her passion for Earth Science.

Linda was accepted to a graduate program at a major university, quit her job, and moved husband and family several states away to follow her passion. After receiving both an MS and PhD in Earth Science, she became a faculty member at a small religious college. Several years later her alma mater recruited her to serve as an academic administrator for a science diversity program, a position she holds today.

**Mary**

Mary grew up off the reservation and attended public schools in both elementary and high school. When she graduated from high school in the 1970s, she wanted to go to college, but her high school counselor told her she was not good enough to go and refused to send her transcripts. Her mother helped her get around the counselor by having the college she had been accepted to request copies. She received her BS in American Indian studies and a human services related field.

Mary went to work for a major university as an academic advisor. Several years later she quit to raise her family and moved to her husband's reservation. When her children began attending school, Mary worried about their education. When a position as a liaison between the Indian community and the school system opened up, Mary took it and became a paraeducator. She later enrolled in a

language revitalization program at the nearby college and received a second degree while working at the school.

Mary then made an appointment to discuss the state of Indian education with the superintendent of the district, and he put her in charge of Indian education programs, a job she has been working for nearly twenty years. During her tenure Mary has worked to develop programs which keep traditional language and culture alive while educating students about Earth Science. Mary is currently pursuing a Master's degree while continuing her work to improve the career options of Native students.

**Noah**

Noah grew up on his reservation and has lived there all of his life except to go away to college for a short time. He graduated from high school in the 1970s. He has always been interested in environmental conservation issues. When Noah graduated from high school he went directly to work for the US Forest Service. He has also worked for several other governmental natural resource agencies between semesters of college work. The need to work to survive has consistently prevented him from completing any of his college degrees.

After twenty years of work in a tourism related industry Noah got a job as a tutor at a local community college. He is now a student support services coordinator for the community college as well as coordinator for a college preparation program at a local high school which is funded through the nearest university. In addition he serves as an advisor for a youth employment program.

Noah works diligently to promote the Earth Sciences as a career path to the students he comes in contact with and is also advisor for the local AISES chapter.

**Oscar**

Oscar was raised fairly traditionally on his reservation, and went to both elementary school and high school on the reservation. He had a great biology teacher in high school and enjoyed trigonometry because it was math which could be applied to real life situations. He graduated from high school in the early 1990s. After high school, his community told him he could go to college, join the military, or take a local job. Oscar's mother had gone to school when he was a child, so he decided on the college pathway.

Even though his first college was only 30 minutes away from his reservation, Oscar found it to be a completely different world filled with covert racism and culture shock. He felt isolated, stopped out, and later continued with his studies at a tribal college on the reservation. He completed an AA in a human services related field, but missed working outdoors. A paid summer internship through the local natural resources department provided him with experience working outdoors in a science field, and experiences with collecting and graphing data in an environmental science class inspired him to want to learn more.

During another paid internship the following summer Oscar found an unassimilated tribal mentor who had a career in an Earth Science field. This relationship prompted Oscar to earn a BS and MS degree in Earth Science. Oscar is currently a faculty member at a tribal college while working to complete his PhD. He is married with children.

### Paul

Paul and his family moved a lot when he was growing up as his father pursued work. He "never lived in the same town more than two years" and "had best friends all over the place". He described these experiences as being instrumental in developing his ability to get along with people and be accepting of different cultures and points of view. Paul went to public elementary schools on the reservation, and attended two different public high schools. It was at one of those high schools that he was inspired with a love of science by a physics teacher. Paul began to attend college classes while still in high school in the late 1980s.

When Paul began his college track, he was focused on studying law and making money, but did not finish his initial program. He then spent over a decade working before returning to school to pursue his passion for Earth Science. Paul has since completed a BS and MS degree and is a faculty member at a tribal college while completing his PhD. He is married with children.

Paul credits his interest in Earth Science to experiences in the outdoors gained while hunting from early childhood and living in areas with environmental problems.

## Demographics

Of the twenty people who participated in in-depth interviews, 15 were of Native American or Alaska Native heritage, while five were not. The demographics reported here are of the Native participants only (Figure 13).

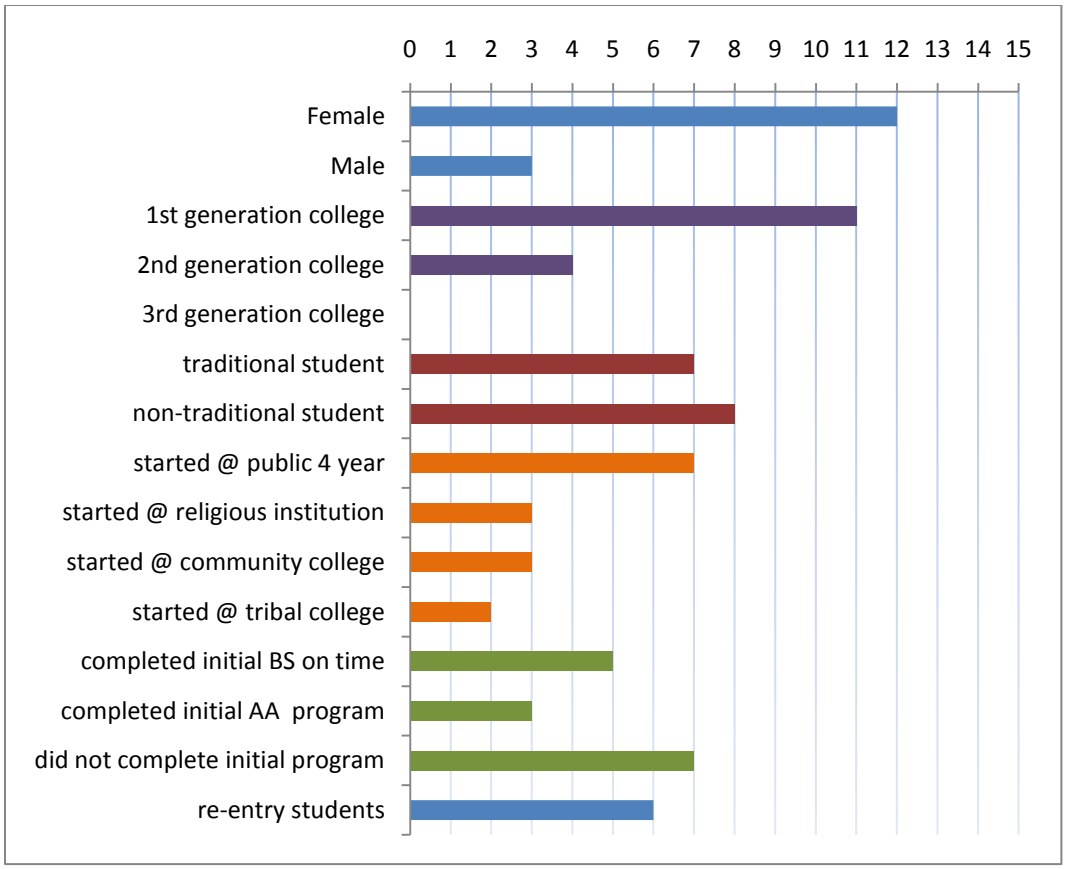



*Figure 13.* Demographics of Native American Earth scientist participants in study

Of the 15 Native participants, 12 (80%) are female and three (20%) male. The overwhelming majority of female participants in this study could be the result of several reasons. First, there are more Native women than men obtaining degrees in higher education. According to the U.S. Department of Education report *Condition of Education 2010*, 66.1% of Associate's degrees, 60.7% of Bachelor's degrees, 65.9% of Master's degrees, and 57.7% of Doctoral degrees which were awarded to Native Americans in 2007-2008 were awarded to Native women. Second, the master list for my sample came from contact information of members of both the Geoscience Alliance and SACNAS organizations, as well as people

whose presentations I attended at various conferences who met the criteria of being both Native and an Earth scientist. In all I contacted 80 people, 47 (58.8%) were women. The 15 participants who responded to my request for an interview (18.8% of the total) were self-selected, and as I am a woman other women might have felt inclined to help me achieve my degree by providing me with the information I needed. It should also be noted here that only people whom I had been physically introduced to responded to my request. No one whom I e-mailed cold responded. Third, many of the women who responded had stories to tell, and they felt comfortable enough with me to tell them.

Eleven (73%) of the participants were first-generation college students, while the rest (27%) reported that one or both of their parents had been the first in the family to attend college, making them second-generation college students (Figure 13). Of these remaining four participants, three reported that one or both parents had attended school while they were a child; the fourth had a father who attended college on the GI Bill. None of the parents had graduate degrees. None of the participants had grandparents who were college graduates. Three participants volunteered that their parents, grandparents, or great-grandparents had been removed from their reservation and forced to attend governmental boarding schools.

About half (47%) of the participants were traditional students, defined here as starting school within a year of high-school graduation and then continuing or completing their education without a significant break. The other half (53%) were non-traditional students, defined here as someone who found

themselves in school twenty years after high school graduation. In each non-traditional student case the student either took an extended period of time off from school to work between degrees (6/8; 75%) or worked full-time while pursuing a degree (2/8; 25%), thereby extending the time required for completion. It should be noted here that the demographics on college campuses is shifting, and "traditional" students no longer make up the majority of students in higher education. More than one third of all students on college campuses are 25 years or older, and three fourths of all students are non-traditional in some way (American Association of State Colleges and Universities, 2006). This shift has prompted some to consider a change of designation from "nontraditional" to "new traditional".

Seven out of fifteen participants (47%) started their college education at a public four-year institution; an additional three (20%) began at a private, religious, four-year institution. Five out of fifteen (33%) completed their Bachelor's degree without transferring or taking an extended break, four at public universities and one at a private, religious institution. Three out of the fifteen (20%) participants began college at a local community college, with 2/3 completing their Associate degree at the same institution. Two out of fifteen (13%) began their studies at their local tribal college, with one completing an Associate degree at that institution. Seven out of fifteen (47%) of participants did not complete their initial choice of programs. Three informants self-reported flunking out due to problems associated with alcohol consumption, three quit to work and/or raise a family and one transferred to another institution and program.

**Majors and Degrees**

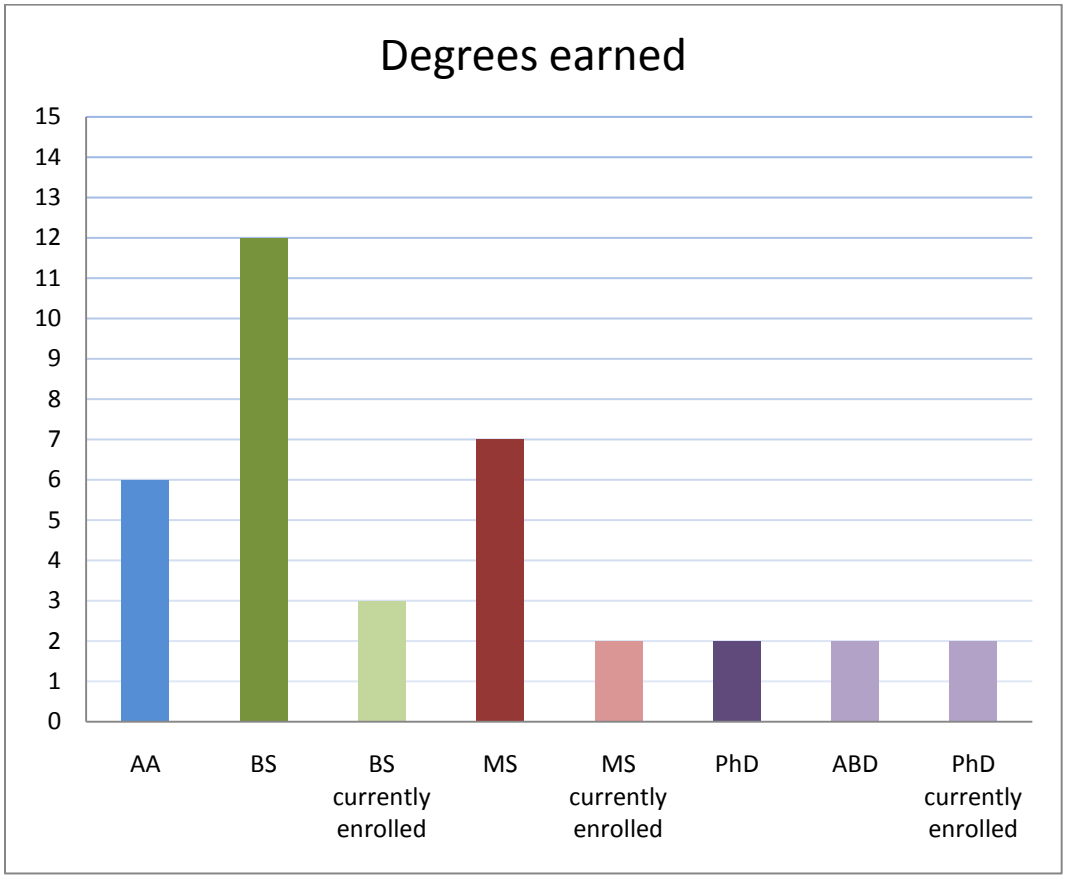



*Figure 14.* Total number of degrees earned by the fifteen Native American Earth Scientist participants in the study by type of degree

In total, the fifteen participants hold 29 degrees and are currently enrolled in an additional seven degree programs (Figure 14). Six Associate of Arts degrees were conferred, 12 Bachelor's degrees, seven Master's, and two PhDs. Participants are currently enrolled in three Bachelor's programs, two Master's programs, and four PhD programs, with two at the ABD (all but dissertation) stage at the time of this writing. Of these degrees, however, 22 are in geoscience or environmental Earth science, while 13 degrees are in other fields.

Only three of the fifteen (20%) participants started their educational path in a geoscience or environmental Earth science field. The remaining 12/15 (80%) started their educations in other majors, sometimes earning degrees in two other fields before making the switch to Earth science. Although half of the participants did begin their studies in a science or math field before beginning to study Earth science, the rest studied human service related disciplines such as social work, psychology, health, education, and law, or art.

**Educational Background**

The fifteen Native American interview participants reported widely varying schooling experiences. The general trend appears to move from instances of going to school on the reservation for elementary school to less instances of reservation schooling once high school level was reached. In some cases this difference seems to have been intentional on the part of the parents, as reported by Barbara:

> I lived on the reservation until I was 12, and went to tribal schools on the reservation. My parents didn't think it was adequate for me to go to high school there, so we found a plot of land in New Mexico, and that is where I went to high school. I started there in 7$^{th}$ grade and finished high school there, then went to college. Between the academic years, during the summer sessions, I went to a private school which offered summer courses.

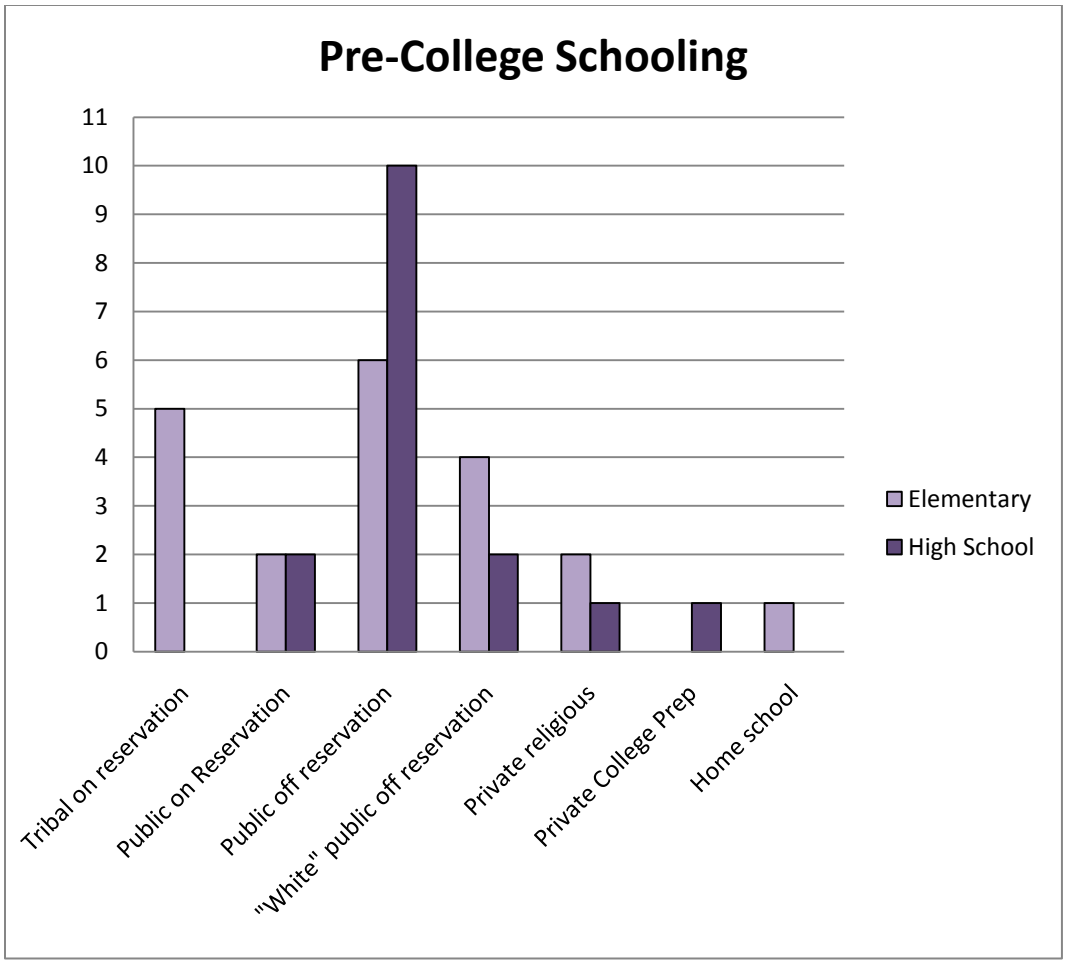



*Figure 15.* Pre-College schooling of fifteen Native American Earth Science participants by type and location

**Elementary School.**

***Elementary school experiences on the reservation.***

Indigo describes her elementary school experience on the reservation as follows:

> I went to a one room reservation school kindergarten through seventh grade, three miles from our house. I had a retired geologist as our school teacher. I loved elementary school, although a lot of it was spent outside, and not necessarily in formal classes. So I would have to say that my elementary school was very interdisciplinary in its orientation, and we had

everyone from kindergarten students through eighth grade in our one room school.

Angela reported a great deal of difference between her schooling on the reservation and that she received off of it.

> I went to a couple of different elementary schools. My mom went back to college when I was six, so we lived in the city from when I was 6 to 10. Then I went back to the village and went to elementary schools in the villages. There was a lot of difference between the elementary schools in the city and the ones in the village. The ones in the village the teachers often taught more than one grade level and there were less students in the classroom, so they were often combinations. I didn't really get much out of them, it was less variety of teaching methods offered than the schools in the city. When we were doing vocabulary and math it was often just repeating or writing down [rote memorization] words to try to memorize them. It wasn't interactive, it was just repeating and writing, so I wouldn't really grasp what I was learning, I would just try to get through the task because there was so much to do. And the school in the city had more opportunities to go out and do different things. We had field trips to the local National Park and museums and other areas; whereas in the village we were just in the village. There were only 200 people in one of the villages that we moved back to, and less than a 100 in the other. So my teacher taught K all the way through 12$^{th}$. That is when I was in 6$^{th}$ to 7$^{th}$ grade. We moved to the city my 8$^{th}$ grade year.

Barbara reported on the extreme culture shock she experienced traveling between the reservation and outside worlds:

> Elementary school was ok, I guess. It was on the reservation. I remember that it was a very different culture. There weren't too many other different races at our school; it was 99% Native Americans. It was a big culture shock transitioning from a reservation school to a border town school. Elementary we didn't really do that much in the class. We weren't being introduced to any math, science, or other types of disciplines. I had a white teacher.

***Elementary school experiences off the reservation.***

Hope, who went to elementary school off the reservation, told a quite different story:

> My elementary school was good. Our principal just passed away last week. He ran it like a military school. By today's standards I don't think he would get away with any of the things he did. He was really strict. If you were really bad he would pull your ear or making them stand with their head on the school building. We were really disciplined, even the way we walked up stairs…I guess our family was pretty big with not a lot of money to go around. I was on the school lunch program where I had free lunch. My mom was always into sewing, so I would always have some homemade clothes and some regular store bought clothes. I was always the kid that would have the holiday shirt, like the Valentine's day shirt or something else. I liked it, but sometimes that sort of stuff got…I

> stuck out. It was a public school. It was mostly white. At that time I don't think there were any other Natives in my grade, and even not that many at the school. Not until junior high where I encountered a few more.

Flora spoke of "passing for White" at her "White" elementary school.

> It was a traditional school. I was born in 1950. All white. Not one person that I knew of, other than myself – and I could always pass [for white] – that was black, Hispanic, Native American, Asian, nothing – we were all whitey tighty. I did not tell them [I was Native].

Feelings of being unfairly treated because of race were reported by Kathy, and differences seem to occur between schools in the same city:

> It was in…a town of roughly 15,000 people when I was growing up. I was in a rather diverse school because we were on the south side of town so we had a lot of mixed minorities at that school, which was good, I thought. When I was in sixth grade we moved to the north side of town and me and one other family member were the only minorities of any kind at that school. You could really tell the difference. Some of the teachers were really very strongly prejudiced.

Five out of the fifteen participants described moving around a lot because of parental employment, both in the United States and out of it. Paul talked about his elementary school experience this way:

> Which one do you want to talk about? I never lived in the same town more than two years, so I moved a lot and I had many schools. I guess you could

> say I had best friends all over the place, and I had to make new friends, and that is probably why I get along with everybody now.

And in the following case of cross-continental and international movement, Cindy added this information:

> Well, I think when I was in one of the northeastern states my mom put me in a Catholic elementary school. My memory is of the nuns being really strict, and we had to wear uniforms. And then in Hong Kong I was in the elementary 3rd, 4th grade. And the classroom was a combined third-fourth grade, and so they pushed you around in groups according to your levels. So you really got mixed up with the kids. Briefly, when I came back to the United States, I went to a Montessori. It was also kind of mixed grades, and you worked at your level. When I went back to a large western city my mom threw me in the public school system. That stunk. I remember because I started mid-semester and the teacher sat everybody alphabetically. With my last name, he didn't want to move half the class, so he stuck me at the problem table, where he had moved the problem kids. And I think he forgot why he *sat* me there, so I was always inadvertently banned as a problem kid.

**High School.**

By the time students were at the high school level, all but one of the participants (93%) reported having attended a single high school, while the remaining participant, who had reported not attending any elementary school for more than two years, attended two high schools. The majority of the high schools

attended were off the reservation. Although high school experiences varied among the fifteen participants, eight (53%) reported that they were placed in Advanced Placement (AP), Honors, or college credit classes. Of those eight, however, several described their placement as being a matter of happenstance or good fortune. Barbara described her placement in Honors classes this way:

> It was different because, in every high school there are clicks or groups that people separate into and I wasn't really used to that. So I had to find my friends. I tried to connect more with teachers. In high school I got a pretty good education. I took Honors courses, and AP courses. It was pretty interesting how I got into Honors courses. In seventh grade the school system offered Honors courses and there was a bit of a mix-up when I first entered the system, because I was supposed to be in a regular English class, but they couldn't find me on the roster, so I just went back to my homeroom class. My homeroom just happened to be an Honors English class, so they just kept me in there. Later on I got into a whole bunch of different Honors classes.

Cindy had the following experience:

> It wasn't really until junior high, that – one thing I missed was I guess they call it Iowa testing, because I didn't live in the country during testing. And it wasn't until, I think, some of my teachers in middle school, where I would get ok letter grades, but not so good behavior grades, that somebody must have wrote in and said "I think she is bored". So they had me do some testing, where they called me in during the summer, and at

> that point placed me where they could in Honors classes. Because I hadn't really started on the math/science track at that point I wasn't ahead like all the other Honors kids. But they put me in the Honors version of science classes, Honors Biology and stuff, English courses. But for Math I was on the regular track, not starting Algebra until maybe even the ninth grade. My mom says that is the fault of sticking me in the public school. But the school I went to was a suburban school, at least the last part of elementary and middle school and high school.

Alternatively, two participants spoke of blatant institutional biases, perpetrated by guidance counselors, which affected their future plans to go to college. Erin reported the following incident and the effects it had on her educational pathway:

> In high school I went to a large school. I think I was mostly just a face in the crowd because there were so many people. I remember in 11$^{th}$ grade I went to the advisors because I wanted to take college prep courses. It was a relatively small town…and they told me that I was not going to go to college; I was going to be a factory worker, so I should take vocational classes. And I remember that that just totally destroyed me at seventeen. I was just astounded. I felt bad when I graduated because I wasn't allowed to take college prep classes, and I felt like I was behind. At that time my sister, who is two years ahead of me, was going to Haskell [Indian Nations University] and encouraged me to go there. So I went to Haskell for one semester, else I probably would not have gone to college, if I hadn't have started there. From there I continued on – slowly – it took me six or seven

> years to get my associates degree, you know with getting married and having kids, working. And trying to decide if I wanted to continue with college or have a career. But I think that what that advisor said was always in my mind. I never forgot that. I think it destroyed me at the time, but it also maybe empowered me a bit too, because I wouldn't have pushed so hard to prove her wrong. I think the town was based on who your family was. I think they just make those decisions. Because of the decision of that counselor I only got to take Biology as a senior and pre-algebra. So I think I came out of that high school with essentially a tenth grade education. And I spent my first year getting my Associates degree playing catch-up. I took every 100 level Biology, every 100 level Chemistry. Every Math. I started with the Basic Math and worked up to College Algebra. Some people come out of school with a disadvantage, but you can always overcome that.

In another instance a high school counselor refused to send transcripts to the university a participant wished to attend, as Mary related:

> I graduated from high school before the Indian Education Act came out in 1972. At that point when I was wanting to go to college my high school counselor told me 'You are not good enough, why are you wanting to do that?' I wanted to go to the University... He would *not* send my transcripts over there for me. So then I bypassed him. My mom had the college ask for my transcripts, which is how I ended in…a better place for me. Things happen to us as Indian people for reasons. Looking back on it I probably

would not have finished school had I gone to the university I wanted to. At that time there was a big initiative to get Indian people to school, and…recruited Indian students hard and heavy.

Both Erin and Mary have since obtained BS degrees, but find themselves enrolled in graduate school as non-traditional students.

**High school science and math courses.**

Participants were asked to talk about the science and math classes they took as high school students. While the answers are likely incomplete due to the length of time between high school and present day, they do serve to give us an idea of the type of high school preparation these Native American participants had (table 3). Course descriptions ran the gamut from "they were very limited" to "I took four years of science in high school". As can be seen in table 3, the cumulative pattern appears typical of that found in the general population, with the most students taking biology and algebra (I & II), then chemistry and physics. Only two participants reported taking Earth Science in high school.

Table 3 High school science and math courses taken by Native American participants (n=15)

| Science | # of participants | Math | # of participants |
|---|---|---|---|
| Biology | 8 | Pre-algebra (highest) | 1 |
| Chemistry | 6 | Algebra | 8 |
| Physics | 6 | Geometry | 5 |
| Earth Sciences | 2 | Algebra II | 7 |
| Anatomy/ Physiology | 1 | Trigonometry | 3 |
| Physical Science | 1 | Pre-calculus | 1 |
| Vocational Physics | 1 | Calculus | 1 |

High school science teachers influenced later decisions to pursue science degrees. For example, Barbara said "In high school I had my first Earth Science class. So that is what got me interested in studying the Earth." Paul reported that his high school physics class was a life-changing experience:

> I know that the one course that I took that changed my life, and lead me down the path I am on was physics. And I had an excellent physics teacher who worked as a nuclear physicist, and he had the ability to inspire and had hands-on things. And so his class is what made me want to be a geophysicist…or I excelled in physics.

Deborah's high school science instruction wasn't as stellar:

> I took a couple of anatomy and physiology classes, kind of human bio classes, because at the time I wanted to be an artist and I wanted to learn how to draw people. I thought I could draw people better if I understood the human skeleton and muscular structure, so those were the classes I leaned toward. I didn't get much out of them because they were taught by the basketball coaches because my high school sucked and they didn't have any real science teachers.

One-third of the participants described selecting and enjoying high school classes which were practical, useful in everyday life, or hands-on. Oscar said, "I liked Trigonometry because it was math that could be applied. I thought it could be useful." Hope described her favorite science class as, "It was like an applied physics class. You calculate discharge rates of water, then you also had a shop

portion of the class where you learned how to weld, where we built an engine using tools and stuff."

Several participants described themselves as having taken minimum math requirements, either because they didn't like math, weren't good at it, did not know the courses existed, or weren't encouraged to take higher level math courses. For example, Kathy related:

> I actually went up to …I remember taking geometry in eighth grade, algebra II and trigonometry in ninth grade. I don't remember anyone recommending that I take pre-calc or calculus. I got by with just the bare minimum requirements for math even though I probably could have gone further. I didn't take AP math … I just wasn't aware of the programs. Then when I went to college I took Calculus.

**Going to College**

Reasons for initially going to college given by participants were surprisingly consistent. In 13/15 (87%) of the cases participants described being influenced by parents, teachers, or their community (see Figure 16).

Cindy said:

> Well, my parents made me do it. At the time I wasn't…I guess I was intimidated by the thought of going to college, so I didn't really want to go and so I actually wanted to be a hairdresser. My dad made this odd deal where, if I went to cosmetology school I was going to have to pay rent, get a job, support myself. But, he said, if you try college, you don't have to

get a job, and I'll pay for you to go to college. And I was kind of lazy, so I said, OK, I'll give this college thing a try.

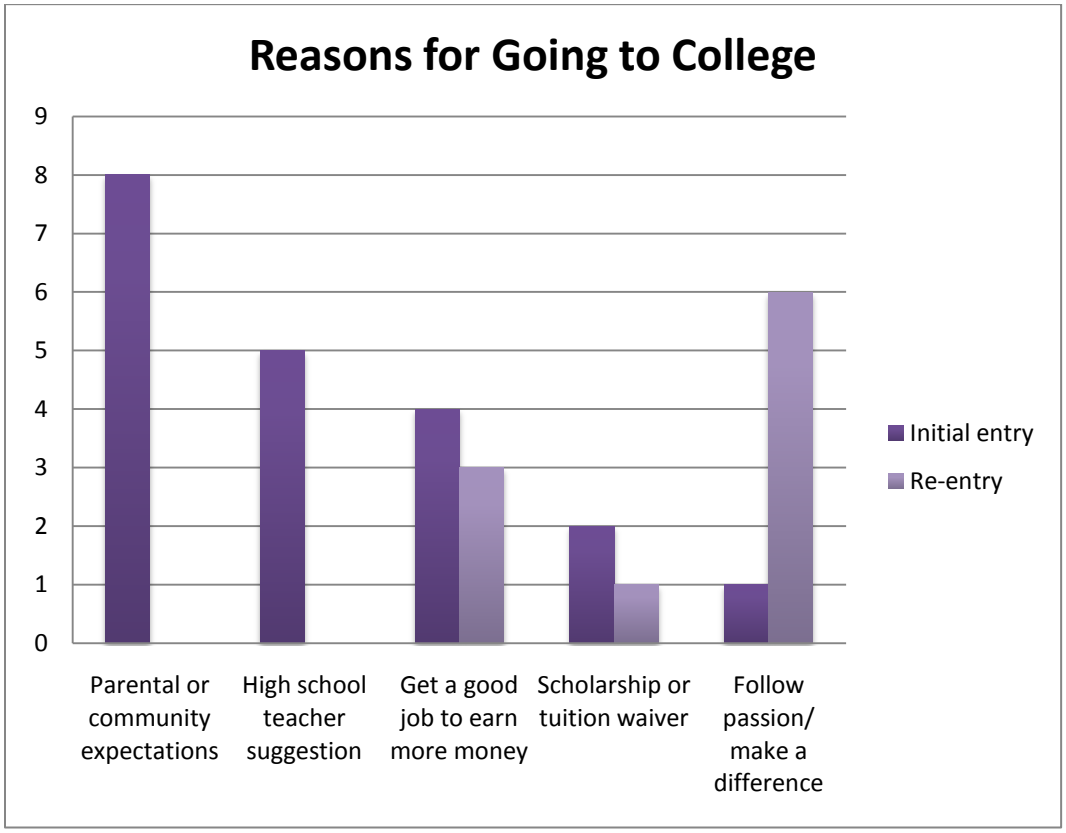



*Figure 16.* Reasons for going to college as given by Native American Earth Science study participants (n=15)

Oscar reported:

> I chose to go to college at the urging of community members. The way it was presented to me, I had three choices: 1) join the military, 2) go to college – my Biology teacher made a strong push for this, or 3) take a local job. My mom went to school when I was a young child, so I had a role model.

Indigo's decision was made for her by her parents, which led to feelings of abandonment:

> I didn't decide to go to college, my parents decided for me. When I graduated from high school I had never spent a night away from my parents, not even overnight anywhere, and I had never travelled out of the state. It was right after I finished my senior year, and I remember it was the beginning part of June. I was out cutting hay with my dad, we were working together in the field, and he said 'What are you going to do in the fall?' And I never heard my dad ask me a question like that because I thought that was a known. I was going to probably marry and live close to my mom and dad. And my dad at that time said 'Take a look around'…I grew up 27 miles from the nearest town on the flat prairie…and I spun around and he said 'What do you see?' And in my mind I was like 'everything I have ever known'. And my dad said 'There is nothing for you here. So come August you are going to the university and you are going to get a degree'. And that is how the decision was made that I was going to college. I am a first generation college student. Neither one of my parents had attended college, but my dad was one that believed that his children were going to have it better than he did. So, yeah…full of *fear*…my mom and dad packed up everything I owned. My mom wrote my name on the bottom of everything. I swept out what I called the Western UHaul, which would have been our horse trailer, the day before my parents packed up everything, put my brothers and sisters in the truck,

> and we all drove across the state. They literally abandoned me at the university.

For Hope, it was a teacher who did not give up on her going to college, even after she had graduated from high school.

> I knew I didn't want to go right away after I graduated high school, so I decided to take a year off. I was just working in a running shoe store. I kept in touch with my old running coach; he would come in often to the store. Even before I graduated he would mention [a particular college]. He would say 'You know they have a running program there, you might want to think about it', and I said 'OK, I'll think about it'. And I didn't think about until the end of the year, and then I decided that I still wanted to have running in my life, I wanted to go to school. I just wanted someplace else to live for a while, and experience. So that is how I got started going to school. Everything just came together. It seemed to be the right decision.

Two participants mentioned that the receipt of college scholarships swayed their decision of whether to pursue college or other options. Angela told of the decision making process this way:

> I always wanted to do the Peace Corps. That is what my plan was, but my mom steered me toward college. Also I got a couple of scholarships straight out of high school, so I barely had to pay for anything my first couple of years. So it was mostly my mom and my advisors at school. They said that it was the best way to go and I didn't know what else to do

> because I didn't want to stay in my home state. There were other educational opportunities outside of my home state. And I always loved learning.

Needing college to get a better job or earn more money than would otherwise be available without an education was also important. Paul said, "I wanted to go into corporate law. That is where the *money* was." Deborah explained her decision this way:

> You know, I don't think I really thought too much about it at the time, but I graduated high school, and…prior to graduating high school I had never thought about college, but then once I graduated I felt that I didn't have any skills to get a good job, so I would have to get a crappy job and I really just didn't want to do that. So I figured I would just go to community college, because that was the only college that was going to take me, for my poor GPA and lack of college prep classes, and just major in art.

Only one participant, whose major was in environmental science, spoke of initially going to college to pursue a passion. Kathy declared, "Basically all I knew when I was a senior in high school is that I wanted to work with the land…but I had no idea what that meant." In contrast to the reasons that Native American geoscientists began their college pathway stands the reasons of those who re-entered college after living in the working world for a while. These six re-entry students, all non-traditional students at that point, had a different story to

tell. To a person, each described their return to academia as a pursuit of passion. Paul explained:

> And one day I decided I was tired of corporate politics and climbing the ladder. So I decided to go back to school, and when I went back to school I decided I wanted to go into something with Earth Science, because that is what I *liked*. And when I went back to school I looked back at my life to that physics teacher; and I decided, I'm into the Earth, I'm into physics, and I *love* water. And so where do I go? I started searching and I found a hydrogeologist and I went and talked to him.

Geneva explained her decision this way:

> I had been working for about twelve years, and I started realizing that, even though I had an AA degree, there was this feeling that I couldn't get past. I was also a little frustrated with what I was doing because I wanted to make a difference, and what I was doing was not actually making a difference for people…So that is when I decided I wanted to go back to college and obtain a degree.

So we see a shift in reasons for pursuing a college degree from one that was initially driven by external parental or community expectations, the desire to earn a good wage, or scholarship incentives to an internally driven desire to follow a passion or make a difference.

**Challenges or obstacles attempting to enroll**

Half of the participants (7/15; 47%) reported no barriers to enrolling in college. Five of these participants enrolled in community colleges or tribal

colleges, while two enrolled in 4-year institutions. One of the two participants who enrolled in 4-year institutions, Flora, had graduated from a "white" high school in the early 1970s and described herself as being a "the poster child for getting into good schools". The other, Geneva, is a non-traditional student who is enrolled in college in the 2010 decade. She commented "I did feel that, being an older student, they were more focused on the younger students and a lot of times I got asked a question as if I was somebody's parent." The other 5/15 participants who reported no barriers to enrolling all attended either community colleges or tribal colleges. Hope commented, "No not really because they make it pretty easy to apply. I didn't have to take any SAT or ACTs to go there. It's a junior college."

Of the 8/15 participants who reported barriers to enrollment, the most common was figuring out where the money was going to come from. Erin responded:

> Yeah, you are always wondering about funding, how you are going to pay for college. When I was thinking about going for my Bachelor's the way that I thought about it was 'If I get accepted, then I am meant to go' Then you get accepted and then you go 'ok, if I get funding…' Then, when I got the funding, I went. And that is what kept me going. You know college is so expensive, and without the support from my tribe I would not have been able to finish my Bachelor's degrees.

For Paul, filling out financial aid paperwork for loans and scholarships was also problematic:

> Oh, yeah…financial aid is a *nightmare*, and going from college to college, you've got to fill this form out, and that form out, and it is a very scary and unwieldy experience… The paperwork *blizzard* is probably one of the biggest hurdles. And I think for someone who didn't have as much *confidence* as I did, it would have completely deterred them. Because there is not a streamlined, easy, this is what you need to do. Financial aid has a form, but then you fill out the form, they tell you after seven weeks you have to call back, and after twelve weeks you go to do this.

Sometimes, even when a student thinks they have finances figured out, they encounter problems once they get to the institution. Kathy related the following example:

> So I went to school, barely able to afford to go there. I remember the first six weeks of school the first time I went there my Bureau of Indian Affairs money hadn't come through, and I was living on a jar of peanut butter and a loaf of bread for six weeks and just determined that that was what I was going to do. I was going to go to school no matter what. But there was a lot of stress involved because I didn't have money for books, I didn't have money to eat…a lot of stress when I first went there. I kept checking every day for six weeks to see if my money came through, and they kept telling me that it didn't even though when I called BIA at home they said 'Oh no, we sent letters there, it's all confirmed'. Yet BIA would not call my school, and my school would not call BIA. For me that was incredibly frustrating, that I couldn't get them to talk to each other about the fact that

> I did have money to go to school. I think that is a big challenge. I think other people would have dropped out at that point.

Barbara reported having difficulty with writing the personal essay required by applications to some institutions. She said "I had some challenges with trying to figure out how to write about yourself, trying to sum up why you want to go to college". In many cases participants described being ineligible to apply for 4-year institutions due to low GPAs or inadequate high school preparation. These students then enrolled in tribal colleges or community colleges instead. Oscar commented "I applied for two schools, a local one and [a 4-year institution]. I didn't get in to [the 4-year institution], so it took me down a bit, but I enrolled in the local college".

A lack of procedural knowledge also caused problems for some Native American students. Kathy reported:

> Once I decided to go I didn't know what I was doing. I didn't know that you are supposed to apply for housing ahead of time. I didn't really know you are supposed to have an advisor. I didn't know about student jobs, I really didn't know anything. All I knew was that the school had biology, forestry and geology there so I could jump around. So I just showed up on their doorstep. The challenges were that my money didn't come through and I barely got a room when I got there. They just did it on a promise that they would get paid. That was a big stretch for the university.

Although half of the participants did not report encountering barriers to their enrollment in college, the other half did. Among the barriers mentioned were

finding funding, writing the required personal essay for college admission, and knowing what to do after being admitted.

**Effect of Location of Institution on Program Completion Rates**

The location of the first academic institution attended in relation to a student's home appears not to have had an effect on initial program completion rates. Students who lived at home were equally as likely to complete their initial program of study as they were not to complete it. The same applies for students who lived a few hours' drive away as well as those who lived over 1000 miles away from home (see Figure 17).

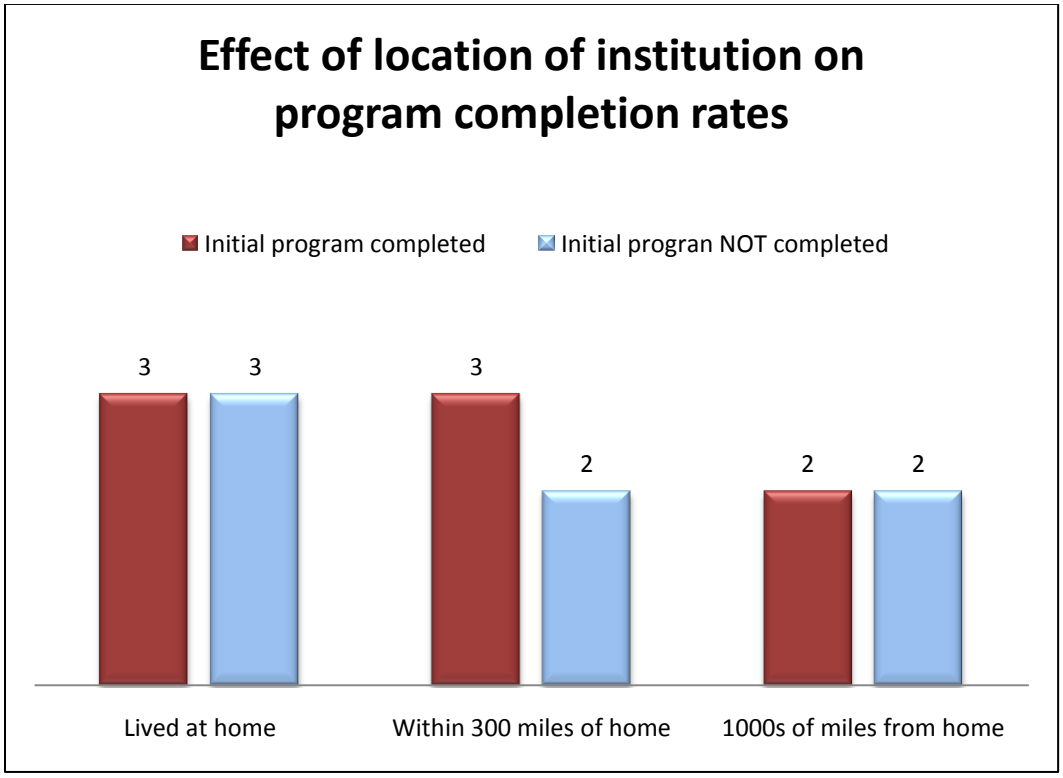



*Figure 17.* Effect of location of institution on program completion rates of Native American Earth Science study participants (n = 15)

Whether it is more desirable to live near family or away from family while attending college seems to be subject to personal preferences and experiences. In some cases even a short distance from home created a very real barrier to student success, as Oscar reported here:

> My first college was thirty minutes away, so it was close to the res. I found the hardest boundary to be the social boundary. It was only 30 minutes away, but it was a completely different world. It was surprising how some people are ignorant. They lived 35 minutes away, but some people thought we still lived in teepees. They asked me about it all the time. It was not overt racism, but…I was surrounded by concrete. It was really different and very difficult to adjust to. I didn't have a car, so I couldn't go home. It felt like I lived in a bubble. I started drinking, and it became a major obstacle.

**Interest in Earth Science**

When asked how they found their way into studying the Earth, participants had a spectrum of answers. Most commonly 12/15 (80%) participants said the resolve to study environmental science was described as a process of discovery or a pathway rather than a clear-cut expressway or "pipeline" through the educational system. Cindy explained her process:

> I guess I probably was like most kids. I liked rocks, I collected rocks. But at the time I just never thought about geology as a *field*. And I took a geology course at the junior college, and I liked it because it was like "Oh, cool, this is about volcanoes". Living in California you think about

> earthquakes and stuff, but I wasn't even thinking about *majoring* in it. When I went to transfer I was still undecided because I liked a number of different things. Another field I was interested in was Astronomy. So I actually sat down and read the whole course catalogue, and the courses that peaked my interest were the plate tectonics, the geophysics courses. And that's when initially I decided I was going to study geology…So when I got to college I contacted the department and they promptly said 'you have to take field courses', but that is what drove it initially, my interest in geophysics.

Only 3/15 (20%) participants claimed to have known from childhood that they wished to study the Earth. Of these three, two described having to go through a process of determining which environmental science pathway they were most interested in pursuing. Angela explained:

> When I first came here I came for marine science but I decided that marine science wasn't really for me. I didn't want to be out on the ocean…I am learning now that I like science, but there are certain aspects, mainly chemistry, that I don't like; but environmental science is a broad field, and I have been taking all these courses to realize what I do like and what I don't like.

The majority of the participants (11/15;73%) described spending large amounts of time outdoors in childhood either hunting for food, camping, or playing. Paul said, "I was always an outdoor person from a child. I was hunting

before I was born, and I was hunting in diapers, and I was hunting every year since". Erin had this to say:

> I grew up in [a state in the southeastern United States]. At the age of eleven we moved into our village in Alaska and…it was so much nature, which we didn't have in the lower 48. I think that is where I actually found science, learning the subsistence fishing and gathering of berries and being able to play in the woods all the time.

A feeling of stewardship obligation as a Native person was felt by 6/15 (40%) of the participants. Geneva told us this:

> I was becoming really disturbed about what I saw as a backward trend instead of being more and more aware of the environment. It seemed like the country, the government, was trying to undo a lot of the progress that had been made in the past. I started trying to figure out what I should do about it, because I feel like it is my responsibility as somebody that lives on the Earth, and as an Indian person, to take care of the Earth. I looked through all kinds of different degree programs. The environmental science thing just kept coming back at me. So it was pretty much a process of trying to figure out where I fit in and where my passions were. I remember watching the tragedy that was unfolding with Hurricane Katrina and not understanding why something like this would be such a huge environmental issue, but being very sad about it. I think that, if anything was motivating it was probably that. Just feeling so helpless. Not knowing what to do, and not knowing how to do it. I didn't have the words back

> then to be able to formulate what I was seeing. But now I understand that a lot of it has to do with environmental injustices that have been perpetuated. A lot of the issues in Indian Country are related to environmental injustices. I didn't understand what it was back then, but I really wanted to understand it. If there is anything that really motivated it, or that flipped the switch for me, I think it was that.

Other childhood experiences which may have had an influence on wanting to study the earth include moving a lot as a child (3/15; 20%) or living in places with environmental problems as a child (4/15; 27%). Paul gave us one example of these experiences:

> And so, because we were and outdoorsy family and the environment was always important to us, and I moved a lot, I lived in places that had environmental problems. I lived where asbestos is, and I only have 85% of my lungs left because of asbestosis. I lived in [a place] which has lead poisoning and from the smokestacks, which is another environmental problem. I lived and worked in another superfund site, and there is arsenic in the water. I lived in Colorado, and in Washington where we have Hanford and other nuclear locations, and so just my personal environment of knowing that the actual environment was being hurt in some way struck a nerve with me.

Experiences in the field were key to the development of many of the Earth scientists. These experiences are the engagement of science by seeing and doing it, which is consistent with the ways that many Native students are traditionally

taught (Kawagley, 2006) Jobs and internships in environmental fields were influential, as (7/15; 47%) of participants reported having either summer jobs as teenagers or internships during early college years which sparked an interest in, or commitment to, pursuing environmental fields as a career choice. Hope was sent to summer science camps as a child. In another case an invitation to participate in an upper-level geology field trip, complete with volcanic explosion, turned a non-major into a geology major. Deborah provided the following example:

> So in the spring I was an art major, and I had to take, besides my art classes, all your standard requisite classes. We had to fulfill some science classes, so I took… *Earth Science*. The professor and I really hit it off. I would go visit him during office hours and just chit chat about things. I was really impressed with just how much *he knew*. He told me one day that some of the higher level classes that he was teaching were going on a trip to Iceland that was subsidized by NSF, and if I wanted to come, even though I wasn't in the classes, I could come. It would cost $1300 for two weeks. I thought that was really cool, and I went home to my grandparents and I thought 'never in a million years' – I didn't have $1300, I was delivering pizzas for a job. I told them about it, and they said "yeah, absolutely we will send you". At the time I didn't realize it, but now I can see that they realized that going to Iceland was going to open doors for me and expose me to things that I had never seen growing up...
>
> So they shelled out the money and said 'this is a great opportunity', so I went. It was two weeks of traveling and seeing the

> geology of Iceland, and every day we went to all these places and saw all these different landforms that I had never seen anything like in my life. And it didn't matter where I pointed, or what I asked them about, the geology professors could make some really educated guesses about 'well, I don't know exactly how old this is, but you can tell it is pretty old because it has been eroded like this and faulted like that' That *really, really* impressed me. These guys didn't know this because they read the book of Iceland *geology,* they were figuring it out. This was something that I could really get in to. Also while we were there, Mount Hekla erupted. I saw a volcanic eruption, and that pretty much sealed the deal. I said "That's it." So I went to Iceland as an art major, and came back as a geology major.

Teachers, both at the high school and college level, can have a great deal of influence on their students' career choices. For example, 3/15 native geoscientists reported becoming interested in science due to the efforts of a particular high school science teacher, while 4/15 became enthralled while taking an introductory Earth Science course as an elective early in their college years. In all four of these cases it was the influence of the teacher and his or her willingness to take the extra time and effort needed to be an excellent mentor, rather than the content of the class itself, which sealed the deal. Barbara described her experience like this:

> I got interested in Earth Science when I took my first Earth Science class in high school. I had a teacher who was about geology, but also about

> helping teenagers clarify their career path. I went to the advisor who helps you pick your classes. He asked me what I was interested in, and I told him geology, studying the Earth. So he enrolled me in a Physical Geology class. That is where I met an awesome professor. He took care of me. He answered my questions about any types of rocks that I brought in. Any time I would walk by his office, if he was there, I would go in and say hi and have really long conversations with him about the different areas we went to. He would tell me about the different types of geology and the different ages, and it just fueled my interest. That semester I declared my major as a geology major.

Various other childhood interests which may have influenced interest in geology were reported by group. Among them were rock collecting, fascination with the stars, love of weather, and having a father who was a Boy Scout leader at a time when scouting was off limits to girls. Flora described this effect on her life as follows:

> There was a path. My father was a Boy Scout leader, so that was all I wanted to be. I said 'because they get to go do cool things, that is what I want to be.' So it is more of an organization. I used to spend hours looking at his Boy Scout handbook because I wanted to do those kinds of things in the outdoors.

Linda described a decision to pursue her childhood passion by following a sign – literally:

When I started college I was a math and physics major. They didn't have an atmospheric science program at the college I went to. Then I decided that physics was getting too hard, so I focused on math. I always liked *science*, but the only option we had at our university was physics. I never even saw geology as an option, even though I took introductory geology as a freshman, that didn't interest me. I liked the weather. It never occurred to me to not actually go to the school I went to -- to move to another state that had a meteorology program -- that never even crossed my mind. Information wasn't available 25 years ago like the internet today. Back then it was much harder to find out who had programs, what you could do if you became a meteorologist; things like that. So I just got my math degree. I worked for nine or ten years in industry, and the last company I was at sent me back to college to start working on an engineering degree. And as I was taking my first class, I was standing outside my classroom, and there was a bulletin board all about atmospheric science and graduate programs in atmospheric science. And that is when it hit me 'Hey, I could do this. Why am I going back to college to get an engineering degree?' So I could do more work for my company. If I am going to go back to school, I decided I wanted to do it in something I was always passionate about – and that was atmospheric science. I applied to seven different schools and got accepted to about half of them.

These Native Earth scientists came to be interested in geoscience through many different pathways, but experiences seem to be a golden key. These experiences took the form of playing or working outdoors, living in places with environmental problems, or geology class field trips. In addition, science teachers at every level proved to be instrumental in instilling interest in the Earth. Perhaps unique to the Native American population interviewed here, however, is a feeling of stewardship obligation to the Earth as part of their cultural heritage.

**Challenges and Barriers to Studying the Earth**

To the question, *Are there factors that impede participation of Native Americans in the Earth Sciences?*, answers which are supported by my data can be divided into three categories: factors which impede the progress of attaining a college degree, factors which impede the decision to study Earth Science, and factors impeding progress which are embedded in the participants' Earth Science degree program. Factors which impede obtaining a tertiary degree of any kind include financial barriers, pressures from familial obligations, and health issues. Factors which impede the decision to study Earth Science include unfamiliarity with *geoscience* and geology as fields of study, the uninviting nature of Earth Sciences as a profession, and curriculum which is neither relevant to Native American lives nor accessible. Factors which impede the progress of obtaining an Earth Science degree include educational preparation, academic information and counseling, inter-departmental relationships, and the prevalence of a Western scientific perspective to the exclusion of all other perspectives.

## Factors Which Impede Obtaining a College Degree

### Financial barriers.

Although some of the factors which impede the progress of Native Americans earning a college degree may be much the same as those encountered by other populations, their effects appear to be intensified within the group of 15 Native American geologists who participated in these interviews. For example, 12/15 (80%) reported having difficulty procuring the funding necessary to complete their Earth Science degrees. Paul reported:

> It's financial. What are you going to do for finances? Are you going to work? Are you going to do financial aid? There's choices. At that point I was single, so I didn't have a family. Had I had a family I don't even know how I would have gotten started. I would have needed family support had I been in that situation, but you can live on hotdogs as a single guy.

In some cases financial pressures necessitate taking out student loans, and large amounts of resulting student debt were reported by 3/15 (20%) of the participants. Deborah viewed her mounting debt this way:

> Finances are always an issue, although I am stubborn enough to be willing to go into more debt for my degrees than I would be to stop going to school. Somebody that was a bit more frugal might have said 'I've got to stop this because I just can't afford this because I am going to have to go into debt'. Whereas I said "Bring on the debt. I want this degree no matter how much it costs". Unfortunately I am in a lot of debt, and I am holding

> out hope that somehow something will happen and I will get this amazing job that will pay it off for me. If not I will be making payments for a very long time.

Even though some financial aid is available in the form of scholarships and grants, the application process for these resources make the process of acquiring an award uninviting. Flora, who also worked full time while attending school, said the following:

> I got one diversity scholarship. Applying for scholarships and grants is like a full-time job, so I did not bother to apply. I looked on line. You have to write a 3 million word essay to get $500, and there is only one given out per year. I just thought my time could be used somewhere else a lot better. That would have been one of the things that would be extremely helpful to me, to have more grant money or more loan money. By the time I get through I will have an intense student loan bill.

Sometimes, even with a "full ride" scholarship of four years, scholarship money can run out if the student decides to take advantage of opportunities which would not be a problem for students of financial means. For example, when Angela decided to enroll in a semester abroad, even though "It opened up a world of opportunities" she faced the following problem upon her return:

> The price of tuition went up, and since my scholarship only covered four years, and I have been here four and a half, this last semester I had to figure out how I was going to pay. So I had to take out a loan because of

my semester abroad in Belgium. It held me back a semester, but it was worth graduating a semester late for the experience.

Residency issues compound the problem of finding educational funding because out-of-state tuition is usually much more expensive than in-state tuition. Hope ran into the following problems with finances:

> My main problem was mostly financial and administrative. One of the biggest hurdles that I had was, since I lived [out of state] so long, I became an [out of state] resident. When I came back I was considered a transfer student and paid out of state tuition. So I was running out of money. I got support from the American Indian Center on campus. The director has been really helpful in that, he not only got me in-state tuition, but he also said that for any other Native in the state, it won't be a problem anymore if they come back home because they won't be paying out-of-state tuition in their own state. That was a big thing for me.

Noah enrolled in a brand new (at the time) out-of-state program only to find the financial burden impossible to overcome. He said:

> I liked it there, and probably would have stayed there, but I was having to pay out-of-state tuition. Then when I went back to school at [home] I declared my major as Natural Resource Conservation, which included a broad range of natural resource subjects. Botany, biology, range, forestry, wildlife, soils, hydrology. But I never completed that.

What followed was a series of stops and starts as Noah attempted to complete a degree while supporting himself with a series of low-paying jobs both

on and off the reservation. Six out of the fifteen (40%) participants interviewed successfully avoided paying out-of-state tuition by completing all of their degrees in their home states. Barbara explained:

> My house is one hour away from [my college], and I could get a tuition waiver. I thought it was a good school to start out with because it is relatively small. I had never met any professors there, but I just applied and got in so I decided to go there even though I had applied to different universities and I got in to University of Minnesota and Arizona State University. But the cost turned me away because I didn't think it was fair to put such a burden on my parents if I didn't know what interests I had. I didn't think it was right to waste money on me trying to figure out what to do with my life. So I chose [my college] because of the tuition waiver. It is basically $800.00 a semester.

Switching majors or seeking a second Bachelor's degree, this time in Earth Science, can compound the problem, as Hope attested to here:

> I also had spent so much money on my degree [out of state] that I am out of funding. So things like the Pell Grant, and also [the state] Indian Scholarship program only cover your first Bachelor's. So basically I am paying for books and stuff out of my own pocket, and private loans. So it has been stressful.

Sometimes a student has to settle for a degree other than one in Earth Science not because they were not interested, but rather because they could not get enough funding to complete all the course work required. This seems

especially true of students who are entering the Earth Sciences field as a second career, as Geneva described in the following excerpt:

> I did not have to take physics. I wanted to, but I switched my path to a more interdisciplinary degree because I was running out of financial aid credits. I had to limit the classes I was taking. I am disappointed that I haven't been able to do that.

Financial assistance largely depends on a student's grades in his coursework. When a student enrolls in difficult, yet required, science and math courses simultaneously their overall grade point average (GPA) is likely to be affected. In a common example, problems with Calculus and Chemistry lower a student's GPA to the point where they are no longer eligible for financial assistance in the form of grants, loans, or scholarships. Once a student has problems with their course work, the effects are compounded and begin to spiral out of control. Hope provided this account of her experience:

> I had problems with Calculus II and Chemistry. I had one really bad semester and ever since then it has been a struggle getting my GPA back up. Since I am a transfer student I need to have my GPA up to a 2.65. As soon as it went below that I was put on probation and I couldn't get any more scholarships because I wasn't in good academic standing. I haven't been in good academic standing for about a year and a half now. I can't apply for scholarships because the financial aid office will just deny them. So ever since them I have been struggling to get my GPA back up, been on probation, been suspended and then appealed it. Fortunately I have had

> some professors who have vouched for me and helped me with the appeal process. With their backing I am doing well. I keep going to school because if I take a semester off…well I actually did take one semester off and that was really hard because I was suspended and, had I spoke up sooner, I could have prevented that, but I didn't. I didn't get help soon enough. That has been a big thing for me, just trying to get my GPA back up, and just trying to get back into good academic standing before I graduate.

The importance of financial assistance cannot be stressed enough. Without the proper fiscal backing a college education is simply out of reach for students without familial economic means. An often expressed opinion is that Native American students get an education handed to them by the government "for free". While some states do provide assistance in the form of tuition waivers and some organizations do provide scholarships, we can see from this data that Native American students are not getting a free ride. In fact, financial pressures often combine with familial obligations and attitudes in such a way that a student's well-being may be jeopardized.

**Pressures from familial obligations.**

Over half (8/15; 53%) of the participants volunteered at least one incident in which pressures from familial obligations affected their ability to concentrate on their studies. Familial obligations cited included financially supporting the family as head of household, balancing family and school obligations, child care needs, and cultural obligations associated with dealing with a death in the family,

or setting a good example for other tribal members. In some cases family members may be supportive for parts of the educational journey, but then start to question motives when students continue to go to school at length. At times the feeling of pressure may become overwhelming. Oscar reported:

> Monetary obstacles – making ends meet. I am married with three children and I take that responsibility seriously. It was a challenge, but I didn't let it distract me. I feel it helped to settle me down in many ways. Sometimes, though, the pressure of the responsibility feels overwhelming.

Often times even a supportive family is unprepared for the challenges a student faces while pursuing an academic degree. Failing grades and low GPAs from a previously successful student then become a family burden as parents expect older children to light the pathways for their younger siblings. Indigo shared her insight:

> All I knew is I wanted to be successful, because when I finished my first semester of undergrad work I had a 1.42 GPA. When I went home for Christmas break those grades came in the mail, along with the following letter saying that I was on financial aid probation, and my dad did not take that well... So when I heard my dad say that this is not what he had expected that was a big motivator for me. Especially since I knew that my family was expending a lot of money that we didn't have for me to go to school. I also watched my brothers and sisters and saw the fear on their face. Being the oldest girl I understood my responsibility of making sure

that my younger brothers and sisters understood that they could do this too. But it was a learning process for both me and my parents.

Some students choose to move away from home to relieve themselves of familial pressures and community obligations. Angela explained:

> It is actually better for me to come away [from home] to gain more independence and focus on school. My extended family has a lot of *drama* that often goes on, and I hear about it, but here I am able to focus more on school and myself than what is going on in my family. If I were at home I would be sucked in to family drama and family matters.

But balancing school and family becomes even more difficult as the married student advances to graduate programs and begins to have children of their own. Linda juggled school tasks and her family by treating graduate school as if it were a job. This behavior is often seen in non-traditional students who return to school after working a "real" job for some time. Linda explained some of the boundaries she was forced to set:

> The other barrier was balancing family and grad school. I also had another child during grad school. That didn't cause any barriers, but I dealt with it like a *job*. I was there from 8 to 5 every day. Doing group projects, sometimes the students would want to meet at eight at night, and I would say 'No. I work from 8 to 5.' So I would make them change to fit into *my* schedule. I told them I had things to do outside of here, I have my kids to see, and this is when I can meet.

Even though some students begin their pathways with the enthusiastic support of both family and community, sometimes support from family members can wane or become non-existent when the length of time spent at college stretches beyond the four years seen as being the norm by popular society. In particular, students and their families may not realize that a doctorate in Earth Science may take nearly a decade to complete. Deborah related her family's change in support as follows:

> Well, I was the first one in my family to go to college, and any college at all was a really big deal, and they were really proud of me, and really supported me. And through our tight-knit community they raised funds to help me advance through college. That was really great. When I did my Bachelor's in *geology* that was still great, although they weren't sure what I was going to *do* with that because nobody in my family had ever heard of geology. But that was ok. But then, moving into my Master's and my doctorate they are still proud of me, and they are still supportive to a degree, but they are completely lost. They have no idea what it is I am doing, what kind of job I am going to get, and 'why in God's name am I still in school?' To them, and to me too, I have been in school forever. And it's like, you know, 'are you just avoiding the real world? Why are you still in school?' They just don't get it. It's like they think that I am just avoiding the inevitable, because they have no idea what a PhD in geology *does*. So to them, "she's just *hiding* – staying in school" And they are getting a little fed up with it.

Sometimes students, particularly those non-traditional students who are returning from the worlds of work and raising a family, need another group which they can depend on for support. In this example Flora reports on the reaction of her family when she announced that she was going back to school to pursue an Earth Science degree:

> By the time I did that my father had passed away. My mother didn't think, could not understand, why I wanted to go back to school. She said 'You don't need to do that.' She hated the choice of school. She said that the East is too liberal and I would be a changed person. If she had lived closer to me I am not sure I would have done it. My [grown] children at that point were very angry because I left their father, so they rolled their eyes and said wicked things about me going back to school. One of my sons really supported me. A lot of my friends that I had made at the Environmental Learning Center said 'You can do it.'

Major familial trauma also serves as a critical juncture for many students on the pathway to a college degree. The death of a family member can be that one last thing the tips the scale to the side of non-completion. It is at these junctures that students require firm guidance and a strong will if they are to proceed with their degree. Deborah described her persistence in the face of tragedy like this:

> I thought about quitting a couple of times, mainly when major things have happened with my family. My grandfather passed away, and I was really afraid that my grandmother was going to pass away shortly after because they were together all their lives and I was really afraid that it was going

> to be one of those things where one mate dies and then the other one dies. I really tried to drop out then, but she wouldn't have it...No, I think I am too stubborn and proud to quit, even if I am not getting the best grades or getting along with my advisor. To me the shame associated with saying I quit my degree, I decided not to do it, is too much and it keeps me going even if I am miserable for a certain amount of time I just don't want to quit something this big.

If the number of Earth scientists from underrepresented and first generation groups, as most Native American students are, is going to be increased it is vitally important that the personnel in Earth Science departments become keenly aware of the cultural pressures individual students may be under and then take active steps to help them address those pressures. Paul, who is a faculty member, clarified the issue like this:

> We need to support the community – whether it be Native, or Hispanic, or even Anglo-Saxon, whatever. We need to support the community with finances and understand the *community*. If you have families to deal with, you need to deal with that. If you [as a student] need to leave for a year and come back you shouldn't be struggling. There are issues that come up. Death in a family, in an Anglo-Saxon community is treated completely different than a week-long I *must* leave to support my family in a Native community. You leave for a week at a major university, you could lose the entire quarter. I have seen this happen over and over. So there is a difference in society that needs to be addressed. And how that gets

addressed is different via institution, instructor, and administration. I think people need to be aware of that.

Many of the familial pressures described here are barriers to the higher education of any group of students. However, once again, these barriers appear to be intensified in this group of Native Americans as students. Native American societies are often community oriented, and Native American students may have very large extended families with which kinship relationships exist. These kinship relationships take on particular importance when a death has occurred in a tribe. Tribal traditions, which do not revolve around an academic calendar, may require students to journey home to participate in obligatory ceremonies. While it is always the student's responsibility to ensure that all academic tasks are completed satisfactorily, a student may be unaware that academic provisions for completion can usually be made in cases of emergency or religious necessity. Therefore it is imperative that each student have a knowledgeable academic advisor within the department to whom he can turn with matters of a personal nature. In the absence of supportive departmental staff the isolated student may become emotionally, mentally, or physically ill (Hipple, 2010).

**Health and mental health issues.**

A student's emotional, mental, and physical well-being can be intimately tied together. Among the Native Americans who were interviewed, 8/15 (53%) described instances of debilitating illness which provided barriers to their academic success. One form of malaise described by several Native geoscientists is a feeling of "not being good enough" to belong in a graduate Earth Sciences

program. This feeling is commonly called the *imposter syndrome* (Clance & Imes, 1978; Laursen, 2008). Even with years of successful experience as a college student, self-doubt can wreak havoc with the mental state of a graduate student. When asked if she had ever been made to feel as if she didn't belong in her Earth Science graduate program, Deborah replied:

> Well, I had my *own* feelings that I didn't belong there. But that was just problems with my own self-confidence. Predominately the feeling I got from other people at different schools that I got my degrees at is they really liked me, and liked my personality and demeanor and work ethic. The biggest deterrent that I've had is the feeling that 'I am not good enough to be here'. Not so much in my undergraduate, but definitely in graduate work I've had a lot of self confidence issues about 'I am not as smart as other students' ' I don't have the background to be here' 'I didn't pay attention enough' 'Any moment I am going to be found out for the idiot that I am' – the *impostor syndrome*. So that is a lot of internal conflict, that's not external.

These feelings of self-doubt were not restricted to younger students, but plagued non-traditional students as well. Says Flora, a mature Earth scientist:

> I needed someone, a mentor to guide me. I felt that, because of my upbringing, because I was going at it late, I needed someone to tell me I could do it. My ex-husband spent a lot of time telling me how stupid and worthless I was, so I needed someone to help me get past the image of myself as being a woman, stupid, and that I didn't belong where I was.

> Sometimes I look at it and think ‘My god, how did I get the courage to do that?’

Sometimes self-doubts turn into full-blown depression when work piles too high and the tasks seem insurmountable. Frustration can lead to sleep deprivation, which leads to physical illness. Unhealthy habits such as smoking or consuming alcohol, when added to the mix, may compound the problem as witnessed in the following account by Deborah:

> I go through big bouts of unproductivity, this big downward spiral that I get caught in where I don’t know what to do. But I don’t want to ask my advisor because I don’t want him to know that I don’t know what to do. So I try to figure it out, but then I get frustrated so I slack off and don’t do anything. But then when things pile up too high I get to a point where I got so much stuff to do that I can’t do anything, and it’s this self-perpetuating downward spiral, and I get depressed and stay up all night staring at my computer so then I don’t sleep. The next day I feel like, I didn’t get anything done yesterday, so I have to do something today, and it turns into this cycle. It eventually ends in me getting sick and being in bed for a week. Then I will get better and it will slowly build back up again, all this stress, not getting any sleep, and me smoking. It’s made me physically ill many times.

But at times physical illnesses may be brought on by unanticipated instances stemming from a cultural shock. Students who have been brought up on a subsistence diet, in which food obtained through hunting and fishing is the norm

and grocery stores are not, may have bodily reactions which can be linked to a drastic change of diet as reported here by an Alaskan Native Earth scientist:

> I would go to the university in the fall and go to Alaska in the summer to go whaling. There was always a bit of a culture shock both ways, but I got used to it. I figured out how to deal with it. For example, when you come home to Alaska all it is is Native food. Its caribou and whale blubber and I think the only American food they had at the store at that time was frozen chicken that you could put in the oven. So when I went back to [a lower 48 state] I would get sick eating the food because it was not what I was used to. Then when I went back home I would get ill for the first week because the food was too rich. So there were cultural things that I had to adapt to, but I ended up doing it rather quickly after a while because I knew what they were and I expected them.

A sympathetic advisor, however, can be instrumental in assuring that a student completes her program, as Cindy illustrated here:

> I got sick while I was in grad school. I kept ending up in the emergency room and they didn't know what was wrong with me. I had some unusual things happen when I was doing my Master's. I would take off for chunks of time. I would say, "Ok, I am going to be gone a semester." And I was fortunate that I had a good advisor that allowed that.

Over half of the Native geoscientists interviewed described instances in which they were under emotional, mental, or physical duress while a student in an Earth Science department. While the above instances of duress could have

happened while seeking a degree in any subject area, other stressors, which will be discussed in the next section, are specific to the students' Earth Science programs.

One can see that the factors which provide barriers to the attainment of a college degree across all populations also affect Native American students who will most likely be coming to Earth Science departments as first generation students from low socio-economic family backgrounds with little cultural capital to help them navigate the higher educational system. For most of these students, no money = no degree. In addition, pressures from financial and familial obligations may become too burdensome to bear, sending the student into dangerous states of emotional, physical, and mental ill being. The effects of these ailments, however, may be warded off if the student is connected to a sympathetic advisor who can use his cultural capital to help illuminate a preferable pathway for the student.

**Factors Which Impede the Decision to Study Earth Science**

***Geoscience* is not known**

Although throughout this study I have tried to use the term *Earth Science* instead of *geoscience*, I mean these two terms to be interchangeable for the purposes of this study. One of the most often discussed barriers (12/15; 80%) to Native Americans becoming Earth scientists is that *geoscience* and *geology* are not known in Native communities. In general most Native American youth do not know what a geoscientist is, what he does, or how to be one. We, as an Earth science community, have a public relations problem. Linda explained:

> I think one of the main issues is that geosciences…is not well advertised. I don't think that students in general understand what they can do with a geosciences degree… I think Environmental Science is more appealing to students. With people really being concerned about our environment, I think that's opening up doors to all different types of populations.

Perhaps a larger road block to increasing the numbers of Native Americans in Earth Science than simply not being familiar with the field is the negative connotation associated with geology in many Native communities. Frequently geologists do not come to reservation lands to protect the land, but rather to locate mineral resources for extraction. In many communities petroleum and mining industries have left a swath of destruction and environmental problems behind them. Cindy elaborated:

> In geology you do a lot of field work, and you would think that would be something that would entice those folks. They call it Earth Sciences in the schools, and sometimes when people hear *geology* I don't think they know what it *means*. It is very entwined with other fields, like you are a geophysicist, or you are a paleontologist, or geobiologist, or geochemist. I think that people really don't know what you do, or else they have an association with some of the more destructive industries, like say petroleum industry, or mining industry.

But it is in part because of these environmental problems that more Native American Earth scientists are desperately needed to help inform tribal leaders

who make economic decisions which may have environmental impacts. Noah is heartened by what he sees as a positive trend:

> I think probably at this point that we are just beginning to see an effort – maybe a nation-wide effort – aimed at Native Americans to make them aware of the opportunities available in the Earth Sciences. We need NSF, we need USGS to come to a high school, come to tribally controlled community colleges and promote their agencies, but also promote their particular disciplines and the opportunities; to tie that to the immediate need on reservations for Native students to become scientists and researchers in those disciplines. Tie them in with the plant and animal life and ecological studies. Out west, we have all these natural resources that I feel are being exploited. Oil, gas, minerals, range lands, wildlife, water, fisheries... [We need] an awareness campaign for Native Americans about how relevant [geoscience] is to Native Americans because of their natural resources.

Deborah agrees that geology is not seen as a viable career choice in Native communities. She also sees a lack of interest in geoscience careers as being pervasive in the general student population:

> I think generally that people don't see geology as a viable career choice. We have a huge problem at my university with bringing in undergraduates, because it doesn't occur to anybody to be a geologist….I had no idea that geology was a career field. When I thought 'scientist' I thought somebody who works for NASA or somebody who works in a

biology lab. I didn't know there were people out tromping around volcanoes. I think a lot of it is exposure.

One of the reasons that students are not enrolling in Earth Science college degree programs may be that, even if they are interested in *science* as a career choice, they have had no exposure at the K-12 level to *Earth Science*. Deborah continued, "[Earth Science] was not an option in high school. It wasn't until college."

In some rural places the educational problem may run deeper than just a lack of Earth Science classes. In the following quote Kathy explained that science has not been taught in some rural Alaska villages until recently:

> They [students] don't have anybody telling them why they might want to go into the geosciences. There is no one saying 'Science might be a good field for you to go into'.…We are just now beginning to get science courses out to rural Alaska after all these years. We have had education out there for thirty years, but we have not had science courses. It is a tremendous lobbying effort to get people to see why geosciences might be a career they might be interested in.

Despite efforts by scientists to recruit Native American students into the field, efforts may fall onto deaf ears unless tribal communities can be convinced that Earth scientists can make money while working with the land. Angela talked about the need to make money:

> I don't think a lot of Native Americans are interested in [Earth science]. I know a lot of my family members aren't interested in science. They are

> interested in making money. Science isn't known for making money. That is the first thing that one of my family members actually told me when I went into this field 'You won't make a lot of money'.

So there appears to be a misperception that being a scientist is not a lucrative occupation. Other fields of employment, however, some of which require science classes and a college degree, are touted by community leaders as careers for young Natives to enter. Some of the suggested careers which require the most education include law (lawyer), health services and education. These careers have two things in common, they all allow the student to come back to the community and contribute to its general well-being. In other communities Native students are recruited to be fire fighters and police, but these are lower paying, certificate jobs. Said Mary:

> There is a huge push to get a lot of Native people into the medical sciences, and into education, and not really so much to get them into the geosciences. There is a big push for other types of careers – law enforcement, fire fighting. That two year 'get your certificate and get a job'. If you ask any kid that age they say, "four years of school again?" They are not wanting to do it. So the information gets out to the kids on these two year certificate jobs. 'You can be a cop, or you can be a nurse's assistant'; but these are the *tech jobs*, these are the *certificate jobs*. These are your *low paying* jobs. Yeah, you can get out there and start it, but you are going to want to go back to school later. I think the geosciences are just like that. You walk up to any kid and say 'Do you know what

geoscience is?' and they are not going to have a clue. That language isn't taught in the public school.

Geoscientists have to start talking, getting out of our comfort level and go talking to the kids. 'This is what you can be doing. Do you want to try?' No one knows what a geoscientist does. In Indian country you are hearing about a nurse, you are hearing about how you can work at the Indian Health Service. You can work in Natural Resources as a tech. You are looking at all those tech jobs in Indian Country, that is it. No one is looking at a four year degree in geosciences, *at all*. And there is no *talk* about it. They don't see a career out there. What is it? What can they do with it? If you just say that – geosciences – what is it? I think there is *no understanding of it at all*.

It is clear that, as a field, geoscience needs to do a better job at self-promotion if we truly want to welcome in underrepresented populations. In Native populations we may also be fighting a negative image of the field as one which is only concerned with resource extraction no matter what cost to the land. Having an emphasis area in Environmental Earth Science may be more appealing to potential Native American Earth scientists than an emphasis area in Geology. In addition, specific information about careers in Earth Science which may be available on tribal lands, and what a student would have to do to prepare to embark upon that educational pathway needs to be disseminated to Native populations.

**Earth Science is not inviting**

When asked why she thought there were so few Native Americans in the geosciences Indigo said the following:

> Because we are not invited. And what we see as being our cultures we don't define as also being the expression of that inherent understanding of science naturally versus an Earth science. Tribal culture is that expression. So regardless of what tribe you come from, or what indigenous group, you are already a scientist. And then helping us all understand that everything that has occurred up until this time is housed inside of us, so that knowledge is there. It's just how do we begin to create those doorways or pathways for people to begin to express what they know.

Science, and the scientists who practice it, are not seen as a particularly inviting group by Mary. Science has its own language and social customs which can be condescending and intimidating to those outside the field:

> Science as a whole is not the same language. You have to learn to play the ropes. They [scientists] are not inviting, that is for sure. Maybe the geosciences even speak a different language from *that*. It looks like it should be a real, real close fit [between Earth Science and Native Americans], but it is not coming across that way [to people from tribal communities]. Unless it is just that welcoming environment that isn't there. Or not accepting any Indian student could actually be good enough. If I suggest I have an Indian student that would do well, why would the next comment be 'Are they good enough?' I take it with a grain of salt, but

would someone else? The condescending attitudes – you can pick them up.

The condescending attitude of scientists which seem to intimate that only the very top students can learn science may deter students from entering the field. Beyond the intimidation and feelings of not being good enough, Native American students may also be put off by the additional schooling time necessary to earn an Earth Science degree. Here, Joe compared Earth scientists to medical doctors:

> I think that it is intimidating. You have a certain stigma or awe of people in scientific professions. Like doctors. 'Oh man, they have to go to school for 11 years, or 7 years, or whatever it is'.

Earth scientists, like all scientists, may appear elitist and condescending to people outside the profession. When these off-putting ways are combined with the amount of schooling necessary to earn an Earth Science doctoral degree, students may opt to move in a different direction.

**Curriculum is neither relevant nor accessible**

One of the problems with trying to get more Native Americans to become involved in the Earth Sciences is that the standard curriculum may be neither relevant to the peoples' lives nor easily accessible by people who often live in very rural areas, sometimes with no roads or modern transportation. In addition, course work needs to be practical and useful to be of much assistance to some Native populations. In this way there is a very big disconnect between the knowledge that is needed and the courses that are offered. Kathy talked about the disconnect in this way:

> The curriculum is not relevant for rural students here. The courses that they [the university Earth Science department] have are the standard courses. They are very stuck into not recognizing social issues in their natural sciences. Part of it is that the curriculum is not relevant and people who might be looking at it don't see the relevance of those courses to their everyday life, even though it *is* very important for their everyday life, but they don't see it in those courses.

At times it is the names of the courses themselves, rather than the content, which can tip a student's decision to pursue a degree or not, especially when a student is not convinced that studying Earth science is her correct path. Kathy continued:

> The other problem is a student trying to understand why geosciences would be an important degree. If you develop a course that is very indigenous it will not get recognized as a science course by the university. If you develop a standard, for example, mining course or geology course it is not going to look like it has any relevancy to Native students, and they won't take it. In fact we had a degree – it is still on the books -- called Renewable Resources – it was an attempt to get a Natural Resource degree out to rural students. We didn't have a lot of graduates out of it. Part of the problem is that it is just the same old program. It was not something that was relevant. It has teachers that don't know anything about the place. What we think about a lot is: How can we develop courses that have stature in Natural Resources or Geology, but are still relevant to rural

students? It seems that, on a national scale, a lot of people are dealing with this – even outside of the Native American community – How do you get young people interested in science? How do you show them it is relevant and it can be fun? That is a challenge; we deal with this sort of turf/ivory tower issue that you deal with at a university. I wish it were easier. If it was easier we could be going so far so fast. We have to negotiate all the time to get courses recognized as something other than Tribal Management. We have to negotiate for Physics credit, we have to negotiate for Chemistry, we have to negotiate for Natural Resources. It is something we have to work hard for; it is just a challenge.

Even when a course is developed and approved for credit by the university, Native students may not have access to the course, Kathy explained:

> The thing is they don't have *access* to those courses. There are a lot of people in rural locations who have a wealth of traditional knowledge. If they had that rounded education of taking what they know traditionally and looking at some of the Western science concepts with it they could be recognized as helping make good decisions for their area and impacting decisions made for their area, it would be really important. But for various reasons [students] don't want to leave their villages, the foremost being that they live a subsistence lifestyle. It is very important for them to hunt. It is very important for them to eat traditional food. It is very important for them to support their elders and their families. And for those reasons they don't leave home or can't leave home. It is our mission to get those

courses out to rural areas, so they don't have to pick themselves up or totally disrupt their lifestyle to get a higher education.

Even when courses are especially designed for rural communities, access to the courses is often problematic. Although it may be tempting to think that an on-line course is the answer to this problem, many of these areas are so rural that internet technology does not exist there yet. One important problem to note beyond the naming, structure, and content of the courses, however; is the fact that many Native students cannot or will not leave their homes due to familial obligations. This one point poses a huge problem in a field such as Earth science, where students are routinely told they must move to another location if they wish to continue graduate school.

**Factors Embedded in Earth Science Programs**

Some barriers to completing an Earth Science degree are not degree dependent, but other barriers can be considered dependent on a degree in Earth Science because successful completion of the curriculum depends on a student surmounting those barriers. Examples of barriers which are embedded in Earth Science programs include educational preparation, academic information and counseling, inter-departmental relationships, and the prevalence of a Western scientific perspective in the classroom to the exclusion of all other perspectives.

**Educational preparation.**

Although proper academic preparation is necessary in any field of study, the effects of poor quality schooling are particularly felt by science majors, such as those students studying Earth Science, where programs typically assume that

students have been exposed to courses in Biology, Chemistry, and Physics before entering into a baccalaureate science program. In addition, prevalent thought seems to be that students entering an Earth Science program should either have already mastered a first semester of Calculus or, at the very least, be prepared to step into a Calculus class and succeed in it without difficulty in order to complete most programs in a timely manner as they are laid out in student handbooks. However, what is often not taken into consideration while programs are being constructed is that a student can be a successful geologist despite struggles in some areas of math or science. Angela commented that she had "No really big problems except for math and chemistry…I had to get a lot of help. I spent a lot of my semesters in the tutoring lab getting a lot of help."

***Math.***

Undoubtedly the biggest barrier which was identified by 11/15 (73%) of the Native participants in this study was a difficulty with math. In some instances, constant frustration with past failure in mathematics has lead to a hatred of mathematics as a discipline. This inability to "do" math can be overcome, however, with patience and persistence. Paul related:

> I am a geophysicist and I have gone through Calc I, Calc II, Calc III, Differential Equations, and I do numerical modeling, and I *hate* math. I don't like math, and I know people that don't like math, but yet they have a *passion* for what they do. And so, because I was *persistent* is the only reason I am here. Again, *specifically* because of math, I forced myself to do it. Which meant that while everybody else did their calculus homework

> in twenty minutes, I was six hours into the night doing my Calculus homework, and just barely passed. And that was a struggle. And that was just because of the way it was taught, not because of Calculus itself.

Mathematics which is learned for the purpose of being able to actively engage in "doing" geology becomes much more palpable to Deborah, an otherwise disengaged math student:

> I had to learn a whole lot of math, which I always successfully avoided in life until then. But it is amazing what you can do when you have a goal in mind, because even though I was not very good in math, and even though I had to repeat a couple of classes, I ultimately came to really love it because it started to make sense after I knew I really had to understand it to see how the geology works. And with *geology* as the goal, the math just became another *obstacle*; it wasn't like this brick wall in front of me. So, it helps to know what you are working towards.

In addition to studying mathematics for the purpose of learning Earth Science; life experiences, maturity, and knowledge from other fields of study can combine to make the study of mathematics more accessible to a student. Geneva relayed her experiences with mathematics as follows:

> My main obstacle was mathematics. When I went to college right out of high school I wanted to study biology, but math was my downfall. My preparation was so weak. Also the mathematics courses at the college that I had chosen to go to were very, very, difficult. There wasn't a lot of support from the professors. There was nothing like a learning commons. I

> am sure they had tutors, but I was ignorant about the process. I didn't know how to ask for that or where to go. So I realized that, when I decided to go back to school to get my [Earth Science] degree, I decided that I had to overcome the math before I could think about anything else. So I went to community college, and I started with Algebra II, and I started taking the Algebra II course, and to my amazement all of a sudden I understood math. That is why I say that I think the computer science, the computer graphics and the programming really helped me with the mathematics. I didn't realize I was learning mathematics, but I was! So when I went back to school I realized 'Oh my gosh! I can do this math. How did that happen?' I had some really good teachers. I had a couple of female mathematics teachers that really helped me to understand. They were able to talk about math visually, and that's what helped me overcome that problem. So that was probably my biggest obstacle to studying the Earth Sciences, getting over that math. Once I did that I realized that I could do the rest. I did take Calculus. I loved it. It is funny because I am getting 4.0's in math. It is amazing because I was getting C- and D in math before.

Calculus was particularly difficult, with four out of the eleven (36%) participants who were required to take Calculus to complete their degree program volunteering that they had a difficult time. Unfortunately, in all four cases, problems with Calculus lowered the students' GPAs to the point where their Earth Science careers were put in jeopardy before they had even begun. Sometimes it was the quality of instruction, and the pedagogy and disposition of the instructor

which dictated the success of the student rather than the subject matter itself. Differences in calculus pedagogy and study habits which ultimately lead to student success were explained this way by Angela:

> I did take Calc II, and the first time I took it I failed and had to re-take it. I did better the second time because I took my time in learning it. I spent every day studying it as opposed to just studying for the tests. And my teacher helped me a lot more. And I had a different teacher. I have taken a lot of different math teachers and they have different teaching methods. The first teacher I had went through the math really fast and we had all these projects to do, but I didn't really understand the math well enough to do the projects, which is why I failed the course. The second teacher I had didn't have projects, but he took his time, he made sure the whole class understood the process and learned. It was slower, but it was helpful. We had a lot more assignments and problems that he went over in class, and more time for us to ask him what was going on. And he explained it in a way that was helpful. The professor in the other course went through the chapters really fast. He gave us in class problems to do, but he only gave us a short amount of time to do them, and I didn't understand them.

In one case a math professor did not believe that Kathy could be successful in Calculus because she was a female. This idea was culturally foreign to Kathy, who had not grown up having the same limitations prevalent in some sectors of White American culture imposed upon her.

> In my freshman year…in my first semester…I was getting D's and F's in Calculus …But the math professor was really not helpful. I dropped the class and felt like a total failure because I always did really good in high school. But then later I found out that he didn't believe that girls could do math, and I had never heard that stereotype. So the next semester…I had heard that if you picked a class with no professor's name on it you are going to get a grad student. So I purposely picked a class that didn't have a professor's name on it, because I figured I might have better luck. And it just so happened that I got this phenomenal grad student instructor. To this day that was my single most favorite class in college– that Calculus class. I loved it. I loved going to it. I loved doing the homework. It turned out then that all the sections had to take the same Calculus final. I found out that I was one point from being the top student at the university on that math final, and the other person was in the same class. So I found out that I could do math, and I did do math. I also took statistics and did very, very well.

A difference in the teaching styles of the two instructors made a huge difference in mathematical understanding for the student. In the first case, where Kathy failed, the professor used a traditional lecture approach with abstract examples. The graduate student, however, provided many examples of where the calculus could be used on a *practical* level.

*Interviewer* [to Kathy]*: Was there a difference in the ways that your two Calculus professors taught?*

> I think the original professor had stiff lectures. I just didn't relate to what he was saying. I didn't understand the concepts. The grad student used a lot of examples of wildlife biology, like counting fish in a stream. His examples were very real-life, easy to understand, easy to relate to why you might want to do math. In fact, I used to tell people 'For the first time I understand why people do math'. I always did math because I was good at it. I never understood why I had to do it. When I took the Calculus course I could see now why people would want to do math and know math, because it was part of doing practical things in life. So he had practical examples, and his style of teaching was more relaxed. It was still rigorous, but it was just a much more approachable way to learn math.

In addition to teaching styles, mathematics achievement, in this case, was also hampered by the professor's inability to see a female student as capable of "doing" math. In another variation of this theme, the Geneva described prejudices encountered by virtue of being Indian:

> I think that mathematics are a really big deal. I am not saying that Indian people can't do mathematics, but I *know* that there are other Indian people out there that have had the same experience I had when I was younger. Just the assumption that 'you can't do it, so why would we put the time in to teaching you?' I think that they are subtle things, but I think that they all add to the issue.

In addition to pedagogical methodology and inherent prejudices, Indigo had cognitive difficulty understanding mathematics which includes using symbols to stand for concepts, as is prevalent in both Calculus and Physics:

> Where I had a real challenge was in math classes. Algebra, geometry, calculus gave me real challenges. In fact I was just visiting with a student this morning who said 'the mixing of letters with numbers is a real issue for me in math' and I had to giggle and say 'yes, it was a big issue for me too'.

So how do students surmount these obstacles with mathematics and survive to obtain their Earth Science degrees despite the problems? Flora explained her experiences this way:

> Pure gutsy grit. Some of my grades in some of those classes were not As, I will say that. They were tough. I was working an overnight shift in [a neighboring state] and I would come back into [town], and I would stop at the university. There was a young man who agreed to tutor several of us who were struggling in math. So I would come back to town after working all night to try to figure math out. That was really hard because I was really tired. I got tutoring; I persisted, and did a fair job.

Mathematics provided a huge barrier for many of the Earth Scientists when they were students. In addition to the inherently difficult material being presented, particularly in Calculus courses, students reported having problems learning in the way that mathematics courses were taught. Work-arounds included seeking tutoring and re-taking the class with a different instructor. Greater student

success seems to have been achieved when mathematics courses were taught in such a way that students could see the relevance for learning and working in an Earth Science field. Students also encountered ideas that they were incapable of succeeding in mathematics instruction either because they were Native American or because they were female. Yet despite the challenges struggling students seemed to persevere through persistence and tutoring.

***Chemistry and Physics.***

While not as reported as problems with mathematics, Native American Earth Scientists also reported having problems with Chemistry (5/15; 33%) and Physics (3/15; 20%). As with Calculus, Physics presented problems due to its abstract nature. Erin reported, "I took one physics class, that's all I had to take but I did have trouble with that. I can't identify with the abstract ideas, I have a hard time working with that." The abstract nature of chemical reactions also caused problems for students. In addition, Angela could not get used to the feeling of confinement and smells of a chemistry laboratory. She commented:

> I am more of a hand-on person. I don't really care for how chemicals interact. I just couldn't grasp my mind around what the molecules were doing. I didn't like the lab environment either. We were in labs for three hours once a week and it gave me headaches because of the smells and the confined space.

The Native American Earth Scientists I interviewed did not report any problems with Biology courses or any of the geology courses in their programs. Of all the sciences they were required to take, Chemistry seemed the most

troublesome. Other than a general lack of preparation for mathematics, chemistry and physics courses, participants also ran into trouble when they did not have the background information necessary to succeed in particular courses within their programs.

***Not prepared for coursework.***

Areas of weakness in the background knowledge necessary for success in Earth Science majors courses were reported by 7/15 (47%) of the participants. This barrier to student success was particularly prevalent for those non-traditional students who decided to study Earth Science because they were passionate about it, regardless of their previous academic preparation. Flora reported the following:

> I really did not have the background to do it. When I got to [my Masters program] I found that most of my peers were a heck of a lot younger than I was, and had also prepared themselves in biology, Earth Science, and geology in undergrad and worked in the field. They were teaching those things in school. I had a lot of hands-on interest because I had farmed and always been interested, but I didn't have the formal training. So I had to work really, really, really hard in some of my classes to get up to speed. I was a total dud in trying to figure out mathematical flows of rivers and things like that. I thought it was fascinating, but it about killed me.

Once again, a creative and concerned advisor proved to be the saving grace for Linda as she followed her passion:

> The biggest challenge was lack of preparation in specific information. I was a math major, so I could do the mathematical part, but I had no

> introductory courses in the weather. My first year of grad school I took a lot of classes. My advisor was great because we did a special two hour meeting once a week and he covered a whole undergraduate curriculum in atmospheric science for me in my first year so that I would be caught up to speed in terminology and things like that. But it was scary at that point. I was thirty years old doing a whole new field studying something I had never studied before, even if I had the tools I didn't have all of the background knowledge.

Because Earth Science is such an interdisciplinary field, the typical Earth science program requires two semesters of Calculus, two semesters of Chemistry, and two semesters of Physics to be completed in addition to a heavy course load of Earth science classes and the requisite general education courses. If a student does not come into a program with college credits in Chemistry, Physics and/or Calculus prior to enrolling in an Earth science degree program it is nearly impossible to finish the degree in the four-year period which financial aid allows for. A student is only eligible for financial aid for 150% of the published time required to finish a program, so if a degree program requires the completion of 120 credit hours, the student may be eligible for financial aid during the first 180 attempted undergraduate credit hours. All attempted credit hours are counted towards this total, including transfer hours, whether or not a course was successfully completed, and whether the student received financial aid or not while taking those hours (The Catholic University of America, 2011; University of North Carolina Charlotte, 2011).

If a student fails, or does poorly in, a Chemistry or Calculus class, as frequently happens, and has to re-take it, that student has now fallen behind both on a completion time-line and with regard to her grade point average. Yet geology graduate programs usually require a 3.0 overall GPA for entry. The student then becomes seriously disadvantaged and locked out of further studies in Earth Science graduate programs. For these reasons it is imperative that students have academic advisors who regularly contact students and provide strong support and guidance.

**Academic information and counseling.**

Native American Earth Science students are very likely to be first generation college students, as 41% of American Indian students are first generation (IHEP, 2007). As such it is probable that a Native student will not have anyone within her family or community familiar with the rigors of an Earth Science program of study with whom she can consult. Participants reported a need for guidance in course selection and planning as well as information about graduate programs, requirements, and the application process. Also expressed was a need for knowledge of and exposure to the different sub-fields within Earth Science and the career paths to which they might lead. Oscar reported that, when he went looking for guidance, "One program on campus threw a booklet at me and said 'here, read that', so I did it on my own."

***Need for guidance.***

*Course overload.*

Working toward a four-year plan for graduation often results in students experiencing course overload as their expectations of being able to complete course workloads may be based on the amount of work necessary to succeed in their high school courses as opposed to college science and math courses. In the following interview excerpt Barbara described what happened when she decided to get her general education courses "over with" while "only" taking one geology class and Calculus:

> I never faced any challenges except for having a large credit load outside of geology. Like one semester I took 18 credits, and I only had one geology class and I took Calculus at the same time. That was pretty challenging. I thought it would be better to get it over with before I got to Junior year because there are harder classes in geology once you advance past the intro classes. I just decided to get all my general education classes out of the way, my writing classes, my arts and humanities classes. It just seemed ok to do that. It worked out pretty well, it was just bad when you have that many credits because you just sleep and go to class and work all day.

Hope found that Calculus and Chemistry was a bad combination for her. In this case a long commute and less than ideal living conditions compounded the problem. She relayed her experiences this way:

> Initially I was trying to take Calculus and Chemistry at the same time. Also my living situation wasn't ideal. I was commuting from [a neighboring city] at the time, also I was trying to find a place to live in [the city where the university was located]. There was just so much going on at that time. I didn't have problems doing well in the Chemistry lab, it was just little things added up, like I didn't finish all of the homework, or I didn't do well on the on-line quizzes and then I wasn't comfortable in the tutoring room, because you get help on one question in an hour, and there were so many other people there.

In Hope's case, an overload of course work resulted in having to repeat classes as well as obtaining an undesirable GPA, which hindered her future plans. Although taking an overload of classes is not specific to students in Earth Science programs, occurrences of class overload are not rare.

*Graduate school.*

Another area where participants talked about needing guidance was in making the decision of whether or not to pursue a graduate degree. Barbara reported her struggle:

> My junior year I was struggling to figure out if I want to go to graduate school, and it was an obstacle because I avoided the question of 'what would you study?' It was part of this overall question of 'what happens after you graduate?' It seems like an obstacle to me, or I just might be afraid of graduating. I approached it by talking to my advisor and my faculty members about the types of research that are out there and the

> places I should be looking at applying to. Or if I haven't figured it out by my senior year I can look for a job at an agency. There was just this unknown feeling I had, but I feel a lot more confident now. I am thinking of waiting a year before applying to grad school. I am still a little indecisive about it. I have a pretty good idea of what I want to do in graduate school, but I would like to work first to see if it is something I want to work towards. I am thinking about some type of reclamation of mine sites. I am interested in soil and water contamination. I am also pursuing a chemistry minor along with my geology degree. I am really interested in all these abandoned mine sites on the reservation, and how mining companies revegetate the land, and sometimes they introduce invasive species to the lands to reduces the costs of re-planting native species.

Upon talking to Barbara it was obvious that she had a very clear idea of what she wanted to do research on in graduate school, yet she did not apply. Speculating at this point I think it possible that, with proper guidance Barbara could have found an acceptable program to apply to. As it stands, it appears that yet another brilliant young underrepresented female geoscientist has been lost to the "leaky pipeline".

At other times a student may know that they wish to pursue a graduate degree, but not know how to do so. In this case Paul knew what he wanted to do, but had to go about narrowing his choices in rigorous and inventive ways:

> I sought out people to say "these are my major interests" and they guided me. So I found people at the major universities who could guide me, and I asked a million questions to everybody I saw everywhere. "What does a hydrologist do? What does a hydrogeologist do? What is the difference between a hydroengineer and somebody who doesn't have an engineering degree? Where are the schools? What does someone actually do on a day-to-day basis?" Those questions, which I sought out because I was persistent, combined with other factors I *selected*, I went geology as a broad field, and then I ended up focusing on geophysics and hydrology.

Non-traditional students often find that their unique needs are not met by the counseling and career services available to the traditional undergraduate. In the following excerpt Geneva reported on issues she encountered when trying to determine which pathway to pursue in her quest to get an education which would provide the most benefit for her people:

> At the school I go to it seems like we always feel the shrinking budget more than the larger schools. I feel like there have been a lot of services cut that would have helped me had they been there. For instance, career planning, planning for graduate school. I have done a lot of research on my own, but it would have been really nice to have some career planning. So that I would know what was out there or how to approach things. All of these types of support services have been really pared down. It has been replaced with peer mentoring, where some people who have been through the process and are still students give you ideas and suggestions about

what you can do. For me it doesn't work very well. I am on a different career path, I am not in my early twenties, so I am thinking about what I can do to contribute my efforts to making things better, rather than 'Gee, I have to get out of here to get a job.' It is a different perspective, and there is really not much in the way of helping older students or indigenous students. We have a couple of people on campus who can do that, but there are a lot of indigenous students and they are spread way too thin.

Again, all these issues point to a real need to have reliable mentors to whom a student can go, who are knowledgeable about the fields of Earth Science as both career and service pathways. Since there are so few Native American Earth Scientists (Czujko & Nicholson, 2011), there are even fewer faculty mentors available to help guide students. Those faculty members who do try to help frequently find themselves overwhelmed by students seeking advice (Stein, 1994).

***Knowledge of sub-disciplines.***

Native American Earth science students found that they were hampered in their pursuit of their passion by discovering that it was too late to pursue it in their course of study. The financial barriers kicked in once again as students could not afford the luxury of extra course work. Summer internships can help spark passion (Zales & Cronin, 2005), but without follow-up funding the efforts may be moot. In addition, introductory classes which focus on rock identification and economic geology may not be optimal for recruitment or retention of Native students. An overwhelming percentage (14/15; 93%) of the Native Earth scientists

I interviewed for this study expressed a desire to work on environmental geology issues. Kathy expressed her frustration this way:

> I just wish I would have had a program where you can explore the different types of sciences that are out there. That would have been neat to have. For example, geology – I took the standard rock identification course and I thought "This is stupid. Why would I want to go around and identify rocks?' But if I had known more about geomorphology or some of these other courses I would have been much more excited about it. But there was no understanding of what that field was about. That would have been better preparation. What kinds of fields there are and what you do in the different fields.

Sometimes when a student enters an Earth Science department with an interest in working to protect the land, she finds the emphasis of the department does not match her expectations. Barbara described a disconnect between her interests in environmental science and the economic geology focus of the professors in her department:

> The different ways you can apply it [geology] in the job environment besides working for the petroleum industry or the mining industry, because it feels like that is the whole emphasis in some of my classes. Finding certain deposits that will help the economy. I haven't heard much about the environmental side like the different types of environmental issues that are out there. That was what got me interested. Also the importance of having a minor with your geology degree is a great thing to

consider. Right now I am getting really interested in being able to teach to high school students. I wish I knew. If I was going to go down that path, I could have taken some education classes.

An ability to gain knowledge of and experience in many different fields available to the Earth scientists is echoed by Geneva, who found her passion during a summer internship:

> What different options were open to me as far as areas of specialization? I did a really great seismology internship with United States Geological Survey. I had no clue what geologists did before I did that internship. I would have liked to have known that, because maybe I would have chosen geophysics instead of something else. I have this real passion for geology, it is so cool. But, again, there are a lot of credits that have to be taken and I don't have that much [financial aid] left because of my experience earlier in life going to college. I would have liked to have known 'Wow, this is what you can do with this degree', because I would have done it.

Unfortunately, in Geneva's case, passion did not mesh with the harsh realities of the availability of funding to finish her degree. Because she had reached the end of financial aid availability she was not able to take the additional courses necessary to obtain a geophysics degree.

So, once again, not knowing what an Earth scientist does on a daily basis, or what different types of careers are available in the field made decisions more difficult for these students. When students did find a passion it was often too late in their program of study to incorporate the necessary classes due to financial

constraints. In addition to adequate career counseling, particularly in Earth science careers with an environmental focus, students could have benefitted from a faculty invitation to consider attending graduate school, followed by informational sessions on how to proceed, and how to pay the tuition.

First generation students did not know about graduate school. They did not know what it is, how to get there, how to pay for it, or that you can shift the focus of your work there if you want. If a person doesn't know enough to dream it, they won't know enough to do it.

In addition to the barriers posed by inadequate access to academic information and counseling, Native students described some intradepartmental relationships as being barriers to their academic success within Earth science departments.

**Intradepartmental relationships.**

The Native American Earth scientists I interviewed, many of whom were women (80%), or non-traditional students (53%) described several areas in which intradepartmental relationships posed barriers to their academic success. The barriers reported ranged from conflicts between sub-fields of Earth science within the department to non-supportive professors and more personal assaults due to gender or age.

***Conflicts between sub-fields.***

Earth Science departments are composed of many different sub-fields. In my study, 3/15 (20%) of the participants described conflicts and competition between sub-fields of Earth sciences within their department. Hope said:

> In my department there is a competition between hydrology students and mineralogy students because the mineralogy students are bigger in number and they get more attention. That's a little difficult to deal with. As far as the other hydrology students, we are all pretty supportive of each other.

Sometimes the conflict is not as much within the spirit of competition as it is ostracism. In the following excerpt from Erin's interview we see an entire sub-discipline of Earth science struggling to fit in to a very traditional geology department:

> Yes. The biggest difficulty was within our own department. Having an astrobiology, geobiology focus we only had one professor...All of the professors were not supportive of the program ... They all wanted just traditional geology and that was difficult, especially taking their classes. We had several run-ins, where we had to have a meeting, and I had to pull my advisor in on that meeting. It was difficult because [the professors] weren't able to identify with biology or chemistry having anything to do with geology. Which I didn't really think made a lot of sense. If your biology is there causing changes in your chemistry, and your chemistry is affecting the rock it is all tied together.

Although competition between work groups is often fostered in all fields of science, those students who have been raised to work cooperatively for the good of the community, as is the cultural tradition of some Native American communities (Little Soldier, 1989), may find the competitive side of science

difficult. Also difficult to deal with is the tension which arises when a student feels a particular professor is not supportive of her success.

***Non-supportive departmental professors.***

One of the most often reported (11/15; 73%) obstacles to student success within an Earth Science department was the non-supportive demeanor of some of the departmental professors. Elements of hostility cited included elitist behavior, lack of interest in undergraduate students, lack of understanding for working students and conflicts negotiating research agendas. Paul described his perceptions of student-teacher relationships at his university:

> Personality barriers that you have at major universities. People think they are better than you just because they are your teacher, and I was the type of personality that wouldn't accept that, so I confronted it head on. Other people, though, that were my friends, had major issues…[In] relationships with professors they don't know how to deal, because instead of treating them [students] like *colleagues*, they [professors] treat them like – you know, elitist.

Barbara described a situation in which the professor unilaterally refused to help undergraduate students in his program:

> My sophomore year I had a professor who I didn't have a good connection with. He seemed very serious about his work, and he was all professional and didn't connect to the students very well. At that time I didn't feel welcome because he just expected you to know it, and every time you tried to get help from him he would give you a look like 'you should try to

figure this out on your own'. I learned from it that there is an expectation that there is so much work that you need to focus on your study. He was the same with everybody in the class. We just didn't get along with him at all.

In another case Cindy described the difference between professors in the sub-discipline she had come to the university to study (geophysics) and the sub-discipline she ended up majoring in (geochemistry). She says:

> I think that sometimes at these bigger research institutions you have professors that are way more interested in their graduate students, and of course their research. So if they teach at all, it is a thing they have to do. One thing I found, even the geophysics prof, who I was hoping to work with, she never was really encouraging or anything. We had a meeting and it was like "Ok, here is what you got to take". And so I think I ended up taking a geophysics course like seismology *ahead* of time, even before I had all the math. Even though I had met the catalogue prerequisites, they weren't *accurate*. It turned out I really needed a whole other year of Calculus, second year. And I struggled with the course, and it wasn't until the final that the teacher realized, "oh you didn't even have enough math to do this course". So at that point, I ended up taking a geochemistry course. But when I went to switch out of emphasis, "ok, cancel the geophysics, I am going to geochemistry"; I remember the geophysics counselor just said, "oh, OK". Not even "what happened?" or "what were your obstacles?" Really not an interest at all in what was going on. And I

found that the geochemistry profs, because I took this introduction to geochemistry course… they really were encouraging.

Flora had to work so many hours outside the university that she frequently found herself asking for academic extensions. This practice caused problems for and with her professor:

> There was just one professor, who – because I was going to school full time and working full time – I often ended up living by extension. So I would extend, and finish whatever coursework I had over the break and then start over again. He said that was a very bad thing to do. I probably got the most heat from him. I agree, it wasn't a great thing to do, but it was the only way I could do it. So I think he was the most negative.

Sometimes a non-supportive professor can turn into a very real obstacle when he is allowed to sit on the committee of a student he has decided does not belong in Earth Science. In the following excerpt Linda described the effect a supportive advisor can have when a student finds herself hurdling created barriers:

> A big obstacle I encountered was with another faculty member who was on my committee, but I think was having issues with the department outside of *me*, but he put up a lot of barriers to me passing my qualifiers and things like that. But my advisor was very good and stood up for me with every barrier this professor put up. That was vital to my success – his backing of all the decisions I made and my research.

In other cases an advisor can be a barrier to a student's ability to carry on research from the indigenous perspective of *reciprocity*, requiring that one give back to the community. In this striking example, even though grant funding had been secured in part because of the promise to collaborate with the indigenous peoples of the study area, once the grant was funded the advisor wanted the student to focus solely on the science. Deborah found herself in a dilemma as she explained here:

> Our research area has to do with an Indian tribe that hunts and works the land. I have been trying to work with them to name some of the landmarks in the area and talk to them about their stories that might involve the area and collaborate with these people. We put all these things on the grant, and now that we got the grant my advisor could care less about doing any of it, and it's all about doing the science. I am having to fight with him. All the reviewers comments , one of the reasons we got the grant, was that they said how great of an idea it was that we were going to work with the people and do these things. 'Do you not understand that we got the grant and we are obliged to do the things we said we were going to do? I understand you think it's all about science, but that is not all there is out there.' He really doesn't understand. He has a very narrow scientist's view of culture. I don't know if I can change that view or not, or if I just have to appease him on the front end and on my own time try to go in and try to do what I can on my own.

The attitude of a professor toward a student's work has a great impact on their success or failure in an Earth Science department. Attitudes which maintain an air of elitist superiority over students do not lead to supportive relationships. Neither do cursory passes at advising, as was seen in Cindy's case.

In addition to uninvolved interactions and poor advising of undergraduate students, professors can become real obstacles to student success, particularly at the graduate level. Departments which are finding that graduate student retention and completion is a problem might want to look at the nature of the interactions between faculty members and graduate students, particularly during the pre-comprehensive exam stage of the process. In the case presented here, Linda had an advisor who stood up for her when she was facing obstacles; many other graduate students are not so fortunate.

***Non-support of women.***

Perhaps more telling than a general lack of support for students by some professors is the blatant discriminatory behavior reported by 4/12 (33%) of the female study participants. While it is tempting to think that these examples of bad behavior are a thing of the past, when analyzed with decades of occurrence in mind we see that at least one instance of overt discrimination based on gender took place each decade from the 1970s through the 2000s.

Kathy in the 1970s:

> But the professor was really not helpful. I didn't know what he was all about. I dropped the class and felt like a total failure because I always did

really good in high school. But then later I found out that he didn't believe that girls could do math, and I had never heard that stereotype before.

Linda in the 1980s:

Interesting story that I laugh at now. My first day on campus, my advisor, who I got along with great, was introducing me to other faculty. An older, white male faculty said to me "You should be at home in the kitchen barefoot and pregnant making dinner for your husband instead of trying to get a graduate degree". That was my first day on campus. Over the course of the six years he actually became one of my mentors. One of the things that I did was educate him that women *could* be students and *should* be students. We are no different from men. Women can do the same things men can do. Maybe that was the reason that I came…so I could educate the faculty and the department.

Indigo in the 1990s:

Oh yeah. I don't think of myself as being very old, but there were very few women at all in the courses. I don't mean to be offensive, but most of the women in the courses were a little bit different than I was, I think in the way that…the things they were willing to do to be successful in the degree. I was raised in a way that I was my dad's oldest daughter. I could do anything that a man could do. My dad would always giggle that he was my first equal opportunity employer. But what I found was that men in the department, the professors, had some very structured beliefs about the

roles of women, and didn't believe that I possessed the motivation or the capacity to understand the material.

Erin in the 2000s:

I had taken this class and the professor was drawing north and south on the board and talking about strike and dip, and he stopped and said '[my name], do you understand what north and south are?' and I said 'well yes, do you?' but it was constant, it was every day, he would stop and say '[my name], do you understand what a mineral is?' and I would say 'yeah, I'm in my second year, I took all those classes' At that point we had a field trip and we had to break out into groups for labs. It got so bad that nobody would work with me because they were afraid of him picking on them. So I decided to ask for a meeting with him and asked my advisor [the only female in the department] to come to that meeting because it was really harassment. And I think that at the [graduate] level we are at it was really inappropriate and I was not willing to put up with it. So we had this meeting and it was really interesting because he didn't know I had invited my advisor. She was late so I thought she forgot and just went ahead and went in his office and he said 'You know your grades are horrible and you really should just quit and go back to biology. Did you even get good grades in biology?' And then she walked in and he said 'This is a closed meeting' And then she said 'Well, I was invited because you were hostile with this student.' His whole demeanor changed, and he was really nice. And then he said 'Well, she has bad grades.' I pulled out all my exams and

labs, and I did not have bad grades. Maybe on his computer I did, but not on the papers he graded. I ended up passing the class and I got the highest grade in the class at that point. And he didn't really talk to me after that. Even after I finished classes he wouldn't talk to me. But all the female students in the department went through that with him. There was an instance when he told one of the female PhD students that women shouldn't be in geology, that she should go be a nurse. I think it was just that good-old-boys club mentality. So that made it difficult. I don't know if that's traditionally how all geology departments are, but here it is a big issue. You either accept it or not, and I just couldn't accept that. It was definitely gender based.

In some instances, women were required to do more than men to graduate from their programs. Indigo commented:

> One professor in particular said 'You will complete these next two classes for your degree, but you will take those classes under me and me alone'. And [me] not understanding, at a fairly young age, what that meant. Then, in visits with my [non-departmental] mentor, understanding that what that meant was that there would be components of that relationship above and beyond what was required on the syllabus. And those ended up being some really challenging semesters. I became aware that the ethics and the values that I had been raised with weren't always in practice at my university. Then it was hard because you felt like you were achieving, and you were learning, but what I was understanding is that the more you

> learn, you realize the less you know. But then here were these true barriers of professors and even sometimes department deans not seeing you as a scientist, not seeing you as a student, not necessarily seeing you as a researcher, but very much characterizing you for how you appear, what you look like. I have learned through others that people would do grades for favors or those things, but where I came from I wasn't versed in any of that.

Bias and discrimination based on gender exists in science. It existed in the 1970s, it existed in the 1980s, it existed in the 1990s, it existed in the 2000s, and it still exists today (Farenga & Joyce, 1999; Hewlett et al, 2008; Hill, Corbett & St. Rose, 2010; Trix & Psenka, 2003). While I am not suggesting that every professor in every Earth Science department holds a bias or discriminates against women, I am suggesting that "we" – the community of Earth scientists – are not "over" thinking that women do not belong in the field. This attitude, while troublesome for all women in the Earth Sciences, became particularly problematic for a Native American woman who, culturally, had been raised knowing that she was as capable as men of working with the land. Said Indigo:

> It also would have been helpful to have someone explain to me that this was a non-traditional field to go into because coming from a farm or ranch, that was all that I had ever understood. I loved the land. I knew rocks. I understood the growing seasons of different plants and grasses. I understood crop rotation. I understood water sheds, just not in

environmental science terms. More in ranch-farm language, but also in a cultural frame, too.

Kathy talked about her experience relating culturally to other students within her program of study:

> I went through a program where it was the same group of students for three semesters. It was a special program, and you had to get accepted into it. Because I wanted to do it, I just dealt with the cultural differences that there were. For example, there were some guys that didn't think women should be out in the field – they didn't think that was a woman's place. And I didn't understand that, because I grew up in Alaska where women are out in the field all the time. So sometimes they would be difficult to deal with. Once I understood that was their issue, I didn't pay attention to it because I realized that it was just something that they had issues with, so I didn't take it personally. When you are Native and you go to a school with non-Natives you are adjusting to them rather than them adjusting to you, so I ended up just doing that. I remember having a discussion with one of the girls in my class my second semester. She was telling me that I needed to be more outspoken as far as educating them on the differences about Native Americans. My attitude was 'that is just too much work, and I don't have time for that right now'. That is where my mind was. I got one-tracked into thinking 'I just want to finish this and go back home, and I want to work the land.'

So from a cultural perspective, Native women might be surprised to find that some of the people around them in Earth Science departments do not think they belong there simply because they are women. The added burden of constantly being asked to explain cultural differences serves as an additional distraction. For the non-traditional Native woman student in an Earth Science department, differences are again compounded by age.

***Resistance due to age.***

When asked if she ever felt any resistance to her presence while a student in an Earth Science program, Flora remarked, "Age-wise I was so very different. I had to be the oldest person there that was studying. There were a few others that were in my age range, but I was the oldest." Geneva found being an older student to be a mixed blessing. She explained:

> Faculty have been really great and supportive. I feel like they appreciate the fact that I am an older student and dedicated to what I am doing, and I ask questions. Sometimes they look at me like 'Wow, I don't know where that came from, but that is a really good question'. I think they welcome the opportunity to be engaged on a different level. Quite often the students also, they are like 'Wow, I never thought about that. I would like to know that too.' There have been students on occasion that have been very resistant to my presence, or to my input. I don't know if it is because of age, if it is that I am female, if it is because I am a Native person. I know the times I have encountered resistance from other students it has been quite a lot of resistance. It hasn't been just a little bit. So it seems like it

has been that they are either accepting of me or they don't want me around at all. So I am not really sure where that comes from. The way I look at it is 'They are on their learning path; I am on mine. These are lessons that they are going to have to learn – how to deal with people. And so they will learn that in their own time.' So I don't let it bother me because I realize that at some point they are going to be an older person. They are going to be wondering what the heck is up. At some point they will learn.

Intradepartmental relationships are often strained for the Native American Earth scientist, particularly if she is a non-traditional female student. Conflicts between sub-fields often pit sub-disciplinary groups of students against each other for fame or fortune within a department. These rivalries often are perpetuated at the top level as professors from different sub-fields compete for lab space and students. Particularly detrimental to students is the situation in which the sub-discipline, and the lone professor who engages in it, are ostracized from the rest of the faculty. The effect of this practice is felt by the student as other faculty members must serve on her committee and may erect barriers which must be surmounted. A supportive faculty member can, however, serve as both shield and sword for a student who has been so besieged.

Women are still being subjected to bias and discrimination within Earth Science departments. Although it seems likely that some hurtful actions are unintentional, others are decidedly not so. Attitudes by professors which indicate that they do not believe women belong in the field may be perplexing to Native women who have been working quite literally in the field their whole life. These

women bring with them practical funds of knowledge which should be tapped in to at the departmental level. Native women Earth scientists also report having issues with prejudices stemming from other students' lack of understanding or willingness to work with them based on their gender or age differences. Interestingly, however, none of the participants reported feeling ostracized or looked down upon by virtue of being Indian.

**Western scientific perspective.**

One barrier which came across clearly in the interviews (12/15; 80%) was that of Earth Science knowledge being taught from a Western scientific perspective only. While none of the participants expected classes to *focus* on indigenous perspectives, the complete absence of discussions of any indigenous contributions, coupled with a failure to even acknowledge indigenous ways of knowing as science, often reinforced feelings of subjugation due to colonization present in many Native communities. Geneva described her thoughts this way:

> I think that the Earth sciences should be a natural fit for Natives, but I think that the fact that it *is* so Westernized. The discussion is always about Western perspectives and it doesn't include Native perspectives. I, myself, as an indigenous person, get really frustrated with that. I feel like we have been told so often how we are going to think and what we are going to think that it is truly intimidating to start studying science and know that is probably what is going to happen. For me, I have learned to overlook that and have my own perspective, like 'I don't really care what you guys are saying, I am going to have my own point-of-view because in the end we

> are both going to get to the same place'. But I think it is really intimidating to Native people. I don't want to be told yet again that my perspective is invalid, because it is not invalid. But I think that it tends to be minimized and shoved off to the side as if it is not really important or it's not really the right way to do science. I think that has a huge impact on why there are not so many Native people interested in the geosciences.

Although acknowledging that she is at a state college and not a tribal college, Geneva also felt that professors should do more to educate themselves about the community of learners they are teaching:

> I have taken classes like Chemistry, biology, and different mathematics classes and there is *no* discussion of Native contribution, Native perspective – nothing like that – it is just all Western-based. For sure I am not going to a tribal college, this is a state college. But still we are … where the largest concentration of Native people in all of [the state] is right here. So I feel that, given the demographic, the instructors need to be more focused on – they need to educate themselves.

At times Native students are asked to explain concepts from their perspective by professors or other students. This practice, however, puts unnecessary burdens on a Native student who may not wish to be singled out from the class. Often the difference in perspectives, and deference to a Western perspective to the exclusion of all others, caused students to question why they are studying science. Geneva continued:

There is always conflict. It makes me conflicted to have to deal with it, because sometimes I am thinking 'Well, we need the science' but then I think 'Why do we need the science? We have our own ways'. It would be nice if there was some way to bridge the two. Often it is left up to the student. In some of my classes I often am the one that is singled out by the professor to have to explain to everybody else certain concepts from the Native perspective. That becomes difficult. I am happy to explain it, but I am also put on the spot. I am not prepared. The instructor is supposed to be prepared and if they haven't taken the time to figure out how to explain that, why should I be stuck out there on a pedestal? In one of my classes, one of the students -- because of my comments – instead of asking the professor about tribal perspectives, will raise her hand and then ask *me* the question. So there is some conflict, there is some tension there. The instructor is really great, he understands that I probably have more insight into it than he does. But I just wish we could get some of these professors to be more educated about that. To me that is an area of conflict that hasn't been addressed and needs some attention. The student should not be put on the spot in a classroom and have to explain five hundred years of history in thirty seconds. It was in an environmental policy class, and I had it happen last semester in a natural resources policy class. Any time the science and the policy starts overlapping, that is where you get into that kind of conflict.

In this case Geneva was not only dealing with her own internal conflict between her indigenous ways of knowing and the material being presented in her class, but she was also being asked to fill in as spokesperson for all Native people, an uncomfortable role. Erin described the tension between Western science and the indigenous student as being the result of tension between the iconic image of a scientist as being a White male with glasses and Native students' self-identity:

> There is such a low number. I think a lot of it is students' inability to identify themselves as a scientist, and students inability to see that subsistence living and the stewardship roles that tribes take is based on science. It is passed down in stories, but if you follow those stories back there is really a science basis to it. Their inability to identify with that hinders how they see themselves. Bringing that realization to them is huge. It is just amazing to see them finally make that connection. Every time you see a picture in a book of a scientist, it is not like any scientist I've ever seen and they are never a Native or Hispanic. They are usually White, pen-pocket protector, pen, glasses and buck tooth. Every picture you see is like that. That's not what a scientist is. It's a cartoon of what a scientist is, and that's what kids see. It's not part of their identity, or how they see themselves.

The mismatch between a student's Indian identity and the stereotypical image of a scientist was only one portion of the internal struggle of Native American Earth scientists. Another part of the picture had to do with the way

Earth Sciences are taught, as 11/15 (73%) of the participants described their thinking as being *holistic*. Cindy related this idea in the following example:

> Yeah, I think in general you tend to see things as more holistic, more interconnected. Sometimes, especially the inorganic sciences, you can be sitting there talking about the location of some element in a crystal structure, and it seems pared down. So it is a lot of stepping back and saying "where is this a part of the overall system?" We have this mineral, and this mineral could react with rainwater, and this could happen, which would then contaminate the water system, which impacts the fish, and the animals, etc. to me, I think I like to think of the whole picture and the impacts on everything.

For Geneva the tension between a holistic perspective and the separation of concepts into fragments of a whole was a real frustration:

> I think it definitely has a *huge* impact. I am used to looking at things holistically. I am used to seeing the connections between things. So for me it is really frustrating how science compartmentalizes things. Western science tends to fragment things into pieces. I understand there is a reason for that because sometimes it is easier to understand things if you take it piece by piece, but from my perspective in Western science there is a lot of fragmentation, but not a lot of putting it back together once you fragment it. But in my mind I always put things back together. I have to see the whole because I think that we are doing ourselves a huge

> disservice if we just look at one thing and don't look at how that one thing affects everything else. I get really frustrated with science like that.

This theme of being forced to attempt to integrate content which has been taught in pieces into a cohesive body of knowledge was repeated by many participants. Indigo suggested that a curriculum built on integrated systems thinking, which is similar to the holistic perspective described by indigenous participants, might improve the matriculation of all students through an Earth Science degree program:

> Growing up in our community it was truly that everything is related. The rains come at a certain time, which changes the composition of the soil, which makes different things grow. And when I came in to the course work, everything back then was still pretty structured. Here is geology. Here is water management. Here is how you look at soil. So it was hard to try to take all of those courses and try to integrate them into one knowledge base. Where growing up it was just a formal part of everything we did. Of course everything is related in the environment. What was different getting to the university and saying 'ok, now I am going to learn just geology. Or now I am learning just watershed management.' And then when you come to soil science, that was my life, you have to know all of this to understand soil science. Having the disciplines separated without having this flow between each of these disciplines, that ended up being a pretty big struggle. And I think that is where now, as colleges and universities look at developing themes through natural resources and

> science colleges, I think that will improve the matriculation of all students through degree programs. What we are finding is that, instead of knowing a lot about just one thing, you need to know a little bit about a lot of things in order to develop that holistic perspective of what is happening with our Earth. People think that climate change is not a real thing. A lot of them are looking at it through the lens of only your one discipline. When you look through a larger picture, everything that is happening is quite apparent.

As Earth scientists investigate problems such as climate change, which involves many parts to a very large system, looking at Earth Science content from an integrated systems perspective makes sense. It also makes sense to begin including humans into the equation when we are dealing with problems in nature. Barbara described the conflict she experienced when the natural world, which Earth scientists deal with, is turned into a series of objects during instruction:

> From a science sense a lot of the natural things that I learned about when I was small all of a sudden turned in to objects, and I saw that as a conflict. There was no longer a relationship between man and nature. Nature became objects. In Earth Science, when it gets into mining, that is when I really saw a whole bunch of conflicts. I was always taught to be respectful to the Earth and it is certainly a whole different perspective when you see a mine blowing up a whole mountain. It is just a whole conflict with me, how you are able to manipulate the Earth for human benefit.

One of the hidden consequences of thinking of parts of the Earth system as objects is the tendency to then justify the manipulation of these objects for human benefit without regard for the consequences to the system which also includes the biosphere, and therefore; man. Native American Earth scientists describe the differences between the two mind-sets as being dichotomous. Kathy explained the Indigenous perspective of respect for nature being imperative for sustained survival of the people as juxtapositioned with a professor's view of natural resource management as being measured by a cost benefit analysis:

> It was very obvious there were differences. When I was going through college for two summers I came back [home] and worked as a forest technician in the villages. One of the riverboat captains we had was the traditional chief. I realize it was the reinforcement of elders like him, and seeing how he viewed the land, and also hunting with my uncles and grandfather and how they viewed the land. I would go to classes with these college professors who viewed the land as board feet and recreation dollars and cost benefit analysis, and that is the way *they* viewed it. So it was totally obvious to me there were different ways of looking at land. I didn't necessarily consider either one of them wrong, they were just extremely different. I look back on it now and I realize that it set the foundation of how I look at land and how I always knew there were two ways of looking at it. Sometimes it is very difficult to integrate them. Most of the jobs I have had have been working with rural people trying to find ways to integrate or manage these vastly different ways of looking at land

> and managing resources. Back then I just had to put up with it. I never thought to argue about it when I was in school, because to me going to school was just a means to an end. I felt I had no time to try to convince them of Native American viewpoints; I would just march to their drum for now. I wasn't outspoken at all. I never said 'Here is another way of looking at things'. I was pretty compliant.

Kathy realized that being acquainted with both Indigenous and Western perspectives allowed her to help her people deal with state and federal laws and regulators. Deborah described how her ability to see two perspectives gives her an edge when contemplating scientific problems:

> From talking to other students and other scientists I feel I have a bit more flexibility in my view of the natural world. Whereas they tend to see things in all black and white, or it's all mathematics, and I get that to a point. I can look at how a stream moves and see how you can describe that, how it can be modeled, but I also think of the life that the stream has and what that has meant to people, and how grateful people are for it, and how civilizations have thrived on it. I get the impressions that scientists don't think as deeply about these things.

Sometimes barriers come in the form of having to resolve an internal conflict between loyalty to a community of indigenous peoples and loyalty to science. When Deborah is exposed to a people's battle for control of their sacred mountain, she began to question the ways of Western science. This inner turmoil

roils again when she attempts to satisfy her obligation to reciprocity under the direction of an uncaring advisor:

> I had a lot of conflict in my undergraduate, because I was working on a mountain which was sacred to the native peoples, and I was taken in as family. These families have a responsibility to take care of the mountain. The scientists built these telescopes on the sacred mountain, so there is a big battle between the indigenous people there and the science. It is a really hard subject to deal with, because you love science, and you want to see the human race thrive and learn things from science and it's thrilling, and exciting. But when you see science come through and just bulldoze over something that really means a lot to people, all of a sudden there is this whole other side of science that you didn't even know existed, that it can be evil, or that it can be callous and uncaring. In my graduate work I am butting heads with my advisor on a somewhat frequent basis because I am trying to do what I can to be involved with my tribe and Native Americans in general, because I really deeply feel that it is my duty as a Native American coming up in science to impress upon future adults how important education and science education is. I need to have these connections, and pathways to do these things, and he could care less.

But Western science and Indigenous perspectives do not have to be in conflict. There are many areas of science that can be complemented and informed by Indigenous knowledge, just as Indigenous ways of doing things can be complemented and informed by Western science. Geneva explained as follows:

> I really would have liked to have known how well these things compliment traditional values and Indian culture, and my culture especially. How the traditional ways combine physics, and Earth science, and astronomy. If I had known that it would have helped me be more direct in my path to my degree.

The differences between Western Scientific perspectives and Indigenous perspectives caused problems for Native Earth scientists as they attempt to integrate what they are being taught in the classroom with their life experiences. While the majority of the participants in this study identified this issue as being problematic, none suggested that Earth Science should be taught from an Indigenous perspective only. Rather, they suggest that Earth Science professors need to consider the community of learners whom they are addressing and make an attempt to acknowledge the contributions of populations other than White scientists from the Western World. This issue is particularly sensitive in Native communities as they continue to struggle with the historical trauma brought about by the subjugation and systematic extermination of both their people and culture by the White Western World.

Native American Earth scientists in this study consistently reported being able to see problems from a holistic perspective. This perspective, in which the interconnected relationships between the parts of the Earth system are taken into consideration when solving a problem, seems to map on nicely to a systems approach to teaching Earth Science. As Geneva pointed out, it is not the fragmentation of knowledge for the sake of teaching it that is troubling, but rather

the failure to discuss how the pieces fit back together that is worrisome. It is also important to note that the biosphere, including humans, is considered part of that Earth system. This consideration of how plants and animals and the Earth are connected seems a critical piece to investigating problems such as climate change. It is important to note here also that *all* of the participants in this study were concerned with the environmental impact aspects of Earth science with an eye towards an internalized sense of tribal stewardship obligations.

**Supports for Native Students Studying the Earth**

To the question, *Are there factors that support participation of Native Americans in the Earth Sciences?,* I found that although financial assistance is imperative for success, mentors and practical experiences which enculturate a student into the Earth Science profession, such as lab experiences and internships, are equally as necessary.

**Financial Assistance**

Financial assistance was imperative to the academic success of most of the participants of this study. Eleven out of the fifteen (73%) participants volunteered that they had received some type of assistance in the form of scholarships or fellowships. The amount of support received, however, ranged from Flora's "one diversity scholarship" to Oscar's "when I went to graduate school I applied for 15 fellowships and got three full-ride scholarships. I turned two of them down." The funding agencies providing support were as widely ranging as the amounts garnered. Federal scholarship funds were received from the Department of Energy and the Environmental Protection Agency, while several states had scholarship

funds set aside for Native students of tribes recognized within their boundaries. In addition one scholarship at a tribal college came from a private donor. Deborah and Erin reported getting support directly from their communities. The most often reported source of scholarship money, however, came from the American Indian Science and Engineering Society (AISES), with four out of the eleven self-reported scholarship recipients having received funds from this organization. Angela was provided with a full four years of support from AISES (see Appendix B for more information on programs).

**Mentors and Mentoring**

Mentorship was an important component of success for Native American Earth scientists. Fourteen out of fifteen (93%) participants described having received mentorship from either a specific individual, special mentoring program, or a network of individuals available through their participation in an organization with a strong mentoring component.

**Individuals**

Individual mentorship was a huge component in the success of these Native American Earth scientists. Twelve out of fifteen (80%) reported having a close relationship with an individual mentor. Paul and Hope found their mentors, and inspiration for future studies, in the form of a high school teacher. For Hope it was a running coach who would not allow her to discontinue thinking about college, even after she had graduated:

> I kept in touch with my old running coach; he would come in often to the store. Even before I graduated…he would say 'You know they have a

> running program there, you might want to think about it', and I said 'OK, I'll think about it'. And I didn't think about until the end of the year, and then I decided that I still wanted to have running in my life, I wanted to go to school.

For Paul it was a high school Physics instructor who provided life-long inspiration:

> I know that the one course that I took that changed my life, and lead me down the path I am on was Physics. And I had an excellent physics teacher who worked as a nuclear physicist, and he had the ability to inspire and had hands-on things. And so his class is what made me want to be a geophysicist.

And when Paul hit a crossroads in his life, he thought back to the influence of that high school teacher:

> So I decided to go back to school, and when I went back to school I decided I wanted to go into something with Earth Science, because that is what I *liked*. And when I went back to school I looked back at my life to that physics teacher; and I decided, I'm into the Earth, I'm into physics, and I *love* water. And so where do I go? I started searching and I found a hydrogeologist and I went and talked to him, and I went down that path.

But professors at community colleges or those who teach undergraduate introductory courses in geology were also the catalyst for both interest in and pursuit of an Earth Science career. Deborah explained her evolving interest this way:

> So in the spring…I had to take…all your standard requisite classes. We had to fulfill some science classes, so I took…*The Earth Sciences*. The professor and I really hit it off. I would go visit him during office hours and just chit chat about things. I was really impressed with just how much *he knew*. He told me one day that some of the higher level classes that he was teaching were going on a trip to Iceland…and if I wanted to come, I could come. …so I went… while we were there, Mount Hekla erupted…I saw a volcanic eruption, and …I said "That's it." So I…came back as a geology major.

But it was an open office door and the willingness to spend time talking to students about geology outside of the classroom that seemed to hold the key to the recruitment of Barbara, who might otherwise have chosen a different path:

> I met my awesome professor. He …answered my questions about any types of rocks that I brought in. Any time I would walk by his office, if he was there, I would go in and say hi and have really long conversations with him about the different areas we went to. He would tell me about the different types of geology and the different ages, and it just fueled my interest. That semester I declared my major as a geology major.

The importance of having a mentor express caring and concern for a student's intellectual interests as well as their physical well-being is addressed in the following excerpt where Kathy, who was having a particularly hard time adjusting to a strange land, was taken in by a kindly professor:

> There was one professor who went out of his way to help me. He had been to Alaska, he loved Alaska. When I came down from Alaska he and his family would have me over for dinner and made me feel welcome. To me he was like an Alaskan…If there was any kind of stand-off behavior from any of the other professors I don't remember it because this one professor took me under his wing and made it comfortable for me to be there.

But academic mentorship was not confined to the halls of Earth Science departments. Indigo described the importance of her mentor-mentee relationships:

> My mom filled out all of the paperwork. My mom filled out the FAFSA. I think my mom wrote down what I was going to look at as a major. I was extremely shy. So getting enrolled in college wasn't a challenge, but once I *got* to college, and I remember my parents driving away and leaving me on the fourth floor of the all female dorm…I had never eaten in a cafeteria before. I'd never been away from home. I had never used community lavatories. There were more women living on the floor of my dorm than had lived in my entire community. So for about the first week and a half of courses I didn't leave the dorm room floor, because I was just paralyzed in fear. And of course calling my parents every half an hour declaring their lack of love for me. So it was about the middle of the second week of courses where, my dad is pretty resourceful. He and my mom called student services, called the TRiO program, at the university, and a wonderful woman and a young [Native] lady that didn't live far from me came over and got me from my dorm. They took me down, showed me

how to eat in the cafeteria, and told me on that day I was going to be removed from courses if I didn't pay my bill. So not only did I learn where the cafeteria was and how to do that process, they took me around and showed me where all my classes were, took me over to the TRiO programs office and said 'ok, this is what you are going to have to do if you want to be successful'. So if it wasn't for [the TRiO director] and Student Support Services I would have been out by mid-semester.

But her encounter with Student Support Services and the TRiO program director was only the beginning of what turned out to be a pivotal day in her academic career. Indigo continued:

First of all I was extremely shy when I went off to college. My students often find that hard to believe. My communications were poor. Back then they involved little less than 'yes' and 'no', and I say my most infamous response to any one question, especially 'What do you think?', was to just raise my shoulders and tilt my head to the side, the classic 'I don't know'.

It was on that day I was paying my bill in one of those old brick buildings, scared to death. When there was one computer and everybody with the last name S had to all get in a line, that one of what I call a *magic door*…one of the magic doors in an administration building opened. You know the ones with the glass and the *etching*? And out of that door stepped an older man, with white hair. He had the classic navy blue suit on and striped tie, the white shirt. And he walked right over to me in the line and asked me if I wanted something to drink. Then I shook my head yes

and he said ‘well, come on in’. So I left my place in line and went through that door, and it was the door of the Dean of the Graduate School and the Vice-President of Academic Affairs. He kept diet coke in his refrigerator and a bowl of M & M s on his desk. And when I walked in he gave me a soda and he asked me if I had work study, at which point I responded with raised shoulders. And he said ‘well, you can start in my office tomorrow, opening mail. I will pay you $6.80 an hour’. I shook my head affirmative yes. What my mom had declared as a major, given that I was extremely shy, was Mass Communications. And so as I worked in the Dean’s office, I think it was the second week when he said ‘We have a problem’. So I went into his office and I was frightened. And he said ‘We do have a problem’. I shook my head ‘yes’, and he said ‘You don’t talk. I want you to be successful not only here at the university, but I want you to be successful in your life, and this culture is different. When you don’t speak, people assume one of two things. Number one: You’re dumb or you’re stupid. And you are not’.

That was a really important statement for someone to make during that first part of my college career, because when you go to college and you haven’t been used to that culture, or even introduced to that culture, it is one that can make you feel doubtful or downright stupid immediately. And he said ‘The second thing is actually more challenging than the first. I know that you listen. So I know that you are hearing. So that leaves that you choose not participate. You need to overcome that. What is your

major?' I said 'Mass Communications' He shook his head and said 'What is it that makes you happy?' Of course I told him at that time 'Being outside'. That was everything that I had grown up with; everything that I had known. He said 'Why wouldn't you consider a major in a science where you could work outside, where you could go back home.' So I put down that I was interested in environmental science.

This example vividly illustrates the need of students, particularly those of first-generation, for support services. Beyond her paralyzing fear, that prevented her from even leaving her dorm room for food, Indigo needed assistance in finding her way around the physical space and dealing with the procedures involved in succeeding in a college environment. Beyond those physical needs, however, she also needed to have someone help her find the right path for her through the academic space. Indigo continued to explain:

> It was really helpful to have the Dean of Graduate Studies and the Vice President of Academic Affairs to talk to every day. So, as I would pursue and move through courses he would ask me on a daily basis 'So how are things going?' And not just that offhand 'how are things going?', but that *declarative* 'Tell me how things are *really* going'. So, I would often visit with him, tell him stories, and he would say 'ok, how could you have done that different? How could you have responded to this in a different way? That is just how he is.' The things that I received were a lot different than what most typical students receive. I began to understand, because he highlighted the not-so-apparent processes of the school. So, as I would run

> into different courses, he would advise me as to the professors to try to take those courses with, and which professors to try to avoid. He would really coach me on how to carry myself in courses, in field work. How to be more action oriented. He gave me a survival guide of how you move through a non-traditional department. What I find now is most students don't know, so they come and ask me. But if you don't have someone, you can't navigate through a process that you don't even know exists. And you need that constant encouragement and kind of reinforcement, because as I went further in the major, of course all kinds of things I didn't anticipate came up.

Even though these last examples dealt with Indigo's experiences before she entered an Earth Science degree path, the lessons learned are invaluable to our understanding of the overall picture of the issues associated with broadening participation in Earth Science. We can see here that being a good mentor entailed much more than discussing which classes a student should take next semester. In the case of a Native American student, who may be battling culture shock on many fronts, mentorship may entail laying out specific pathways for students to follow and advising them of the pitfalls they may encounter before they become insurmountable barriers. Beyond that, as illustrated in the preceding quotation, a constant communication is necessary to develop the type of relationship necessary to truly be a useful mentor.

Sometimes undergraduate students found mentors in graduate students or postdocs for whom they were working in a lab situation. Those relationships were

instrumental to student success as well. Cindy related her undergraduate experience:

> One of the profs there actually hired me. He had a Post-doc that was working with him, and he hired me to assist her in the laboratory. And so I helped clean the laboratory, you know, you really had to be concerned about contaminants. But she was very good. She is a full-fledged professor now. She has a great career in academia. But she was really nice, and she would explain to me what she was doing, and how my small part of running these columns for the isotope work she was working on, how it was going to contribute to the bigger study she was doing.

In this case the Post-doc had a great influence on Cindy by serving not only as a research mentor, but also as a female Earth scientist role model. A role model with whom a student can identify can be a particularly powerful mentor, as Oscar explained:

> I am on the fast track to completing my program now. Role models are very important. The director of the Environmental Protection Program at the tribe was [from the same tribe as me]. I saw his degrees on the walls, and he encouraged me. And he looked like me – not assimilated, but a participating member of the tribe. He was a practicing scientist in the geosciences field.

Role models with whom a Native American student can identify are rare, however, as the numbers are so small. Fortunately, a caring non-Native mentor can also be effective in assuring student success. As students shifted from

undergraduate programs to graduate programs their needs shifted as well. Although some students remained life-long friends with their undergraduate mentors, when they entered graduate programs the process of finding a good mentor began anew.

By the time students shifted into graduate degree programs, their college enculturation had largely taken place and mentors became very important for other reasons. In one case a faculty advisor helped Linda catch up on the basic content knowledge she needed to succeed by spending time tutoring her individually:

> My advisor was great because we did a special two hour meeting once a week and he covered a whole undergraduate curriculum in atmospheric science for me in my first year so that I would be caught up to speed in terminology and things like that.

In more than one case, as we have seen, advisors were instrumental in removing barriers to student success erected by other faculty members in the department. As Linda reported, her "advisor was very good and stood up for me with every barrier this professor put up". In addition to the mentors that students found within their university departments, special mentoring programs tasked with increasing the number of underrepresented students in science have been set up to assist students in navigating academic waters.

**Special programs**

The mentoring provided by special programs was vital to the success of many students in this study. These programs ranged from those that are federally

funded at a national level to regional consortiums of institutions and specialized college prep programs. Nine out of the fifteen (60%) Native American Earth scientists interviewed reported having been mentored by a special program. The services that each program provided varied with their mandate (see Appendix B). Some, like the McNair Scholars program, were focused on providing undergraduate students with the skills and information they needed to continue their education into graduate programs. Paul discussed his McNair experience:

> I guess the first time I used any pro-active Native program was McNair. So, as an undergrad I was in the McNair program, who paid for all my graduate applications. And you know they make you do six. That was probably one of *the* major helps, otherwise I wouldn't have *applied*. The university that I went to has now *lost* their McNair program, which is sad. But both my brother and I went through that program, and he is now doing his double Master's. He will finish this year, too. So McNair was number one.

The McNair Scholar's Program is under the TRiO umbrella of educational opportunity outreach programs. As we saw earlier, the TRiO program director at the university Indigo attended literally came to her dorm room and pulled her out of it when she was paralyzed with fear. Another program which affected the success of 5/15 (33%) of the participants of this study was the Louis Stokes Alliances for Minority Participation (LSAMP) program. This is a large umbrella program funded by the National Science Foundation (NSF). Universities and their partnerships, in turn, develop local programs to serve the students in their areas.

In this next interview excerpt Paul described how one of these LSAMP programs was structured:

> The Alaska Native Science and Engineering Program (ANSEP), which is part of the Louis-Stokes Foundation program, a subsidiary, I was part of that in my Master's and it was kind of a faculty thing for a bridging program for Natives that were coming to the university. So they would come to our bridging program and I taught a geosciences block of that. And I got experience with Alaska Natives across the entire state. And that had mentoring programs built in to it. So you had to go to a meeting every month, and you *had* to meet. If you were in any of the STEM disciplines, then the people that were in the STEM disciplines from ANSEP at the higher level, that had already gone through, say, Calc I, they mentored students that were coming up. And then they would be taking Calc II and be mentored from somebody who had already gone through that, and the program then became sustainable because people that then went on to get careers donated back to ANSEP to make it more sustainable. I think it was probably the model that I found most effective.

Another NSF funded program which had a positive impact on the participants of this study was the Alliance for Graduate Education and the Professoriate (AGEP) program which is focused on producing minority PhDs who then go on to join the professoriate. This program works as an umbrella as well, with universities, colleges and minority-serving institutions such as tribal colleges forming partnerships to help map out pathways for students. Paul continued:

> I have since been in the SAPAI program, which is Students to Academic Professorate for American Indians, [an AGEP program] and that was a bridging program that takes people who are working on their dissertation, or who have finished their dissertation, and places them in a tribal college with partial funding so that they can become part of the faculty at an institution without the institution having to pay, and that was a really good program.

In addition to federally funded programs, some schools have an American Indian Center at which students found companionship and a sense of community. Indigo said:

> I can't stress enough the importance of the TRiO program, and the Indian Center. That became critical to my success there. Not only in terms of motivation. Why, and reasons to study, but becoming involved in a larger community. The stress of classes was often reduced. On Thursday, I would be at the Center by six o'clock in the morning so we could prepare for taco week, or we could prepare for a workshop. So the culture piece of my undergrad and my Master's program was really important, and the university did great in that capacity.

Along with a sense of community, the directors and staff of these programs sometimes became a student's last line of defense when problems arose. In this example Hope reported what happened after failing Chemistry and Calculus put her on academic probation and made her ineligible for financial aid because of a low GPA:

> I am trying to re-take some classes. I am also getting extra help, like tutoring. I also have the director of the American Indian Center speaking on my behalf. He helps me out with these administrative hurdles. He knows the person to talk to, like in the billing office. Like when I can't register because I have a financial hold on my account, he called and said 'She has been paying you money, you should take the hold off her account so she can register for classes' and they said 'ok, no problem'.

One other type of program bears mentioning here. Barbara reported enrolling in an eight week summer program for four years before attending college. Her experiences there could be considered mentoring by a special program as she described here:

> Between the academic years, during the summer sessions, I went to a private school which offered summer courses. I went to a Christian academy [on the East Coast] and did an 8 week summer program there for four years. They introduced you to college topics and immersed you into different cultures because you got to meet students from Saudi Arabia, Venezuela, Brazil, Japan, all over the place. It was really good experience. *There* is when I started realizing that I didn't need to be home all the time. I didn't have the big homesickness that some Native students have. During that time I got used to being away from home.

So even though this last experience was at the high school level, it still served to acclimate Barbara to life away from home in an academic setting, and

the rest of her interview positively reflected those experiences, as she did not report encountering many of the barriers other participants *did* encounter.

**Professional organizations**

Professional organizations were also instrumental in the success of Native American Earth Science students. Twelve out of the fifteen (80%) participants volunteered that they had received mentoring from professional organizations. These organizations were formed by concerned individuals to support specific sub-populations of scientists. The American Indian Science and Engineering Society (AISES) and the Geoscience Alliance, organizations developed specifically to increase the representation of Native Americans in science, were the most frequently mentioned by participants, but it should be noted here that I met most of my participants through my association with the Geoscience Alliance. Also mentioned was the Society for the Advancement of Chicanos and Native Americans in Science (SACNAS), Association for Women Geoscientists (AWG) and Women in Science (WIS). Barbara talked about her experiences with mentoring organizations this way:

> I got really involved with AISES and I am also starting to participate in the Association of Women Geoscientists. At first when I was a freshmen AISES claimed to be all about the sciences, but nobody was looking for geosciences majors at any of their conferences, which was really surprising. I went to all the booths and nobody was looking for geosciences majors. So I thought 'maybe I won't be a part of AISES any more'. I stayed a part of the campus chapter. I started to see that AISES is

> bringing USGS [United States Geological Survey] to their career fairs and I am starting to see opportunities out there, so that is a good thing to see now. Through AISES I was able to network with USGS last year. I met a fellow woman geoscientist there and we made a connection and I still have that connection today. I always go to AWG [Association of Women Geoscientists]…I went to the [meeting] and networked with a bunch of women there... I went to a different conference in September with the Geoscience Alliance and networked there. SACNAS started to start a chapter this year, but I never heard anything more about it.

In this case Barbara actively looked for mentoring in the Earth Sciences. Even though she did not succeed in finding a connection at first and was disappointed, she persisted. Barbara later found a woman Earth scientist who connected her to another mentoring organization, where she formed relationships with other women in the Earth sciences. Finding other women scientists to connect with may be very important to the development of a Native American woman Earth scientist. Linda found such a connection on her campus. She explained her involvement with the organization this way:

> We had the Women in Science program. We met once a month in the College of Science. We had speakers who came in and shared their story with us. Or someone giving us specific pointers on things like how to do an interview. That whole program was vital for support. There were 40 to 50 female graduate students in the program. It allowed us to meet other female faculty, so we got role models. It allowed us to meet each other so

> we could network and get peer mentoring across the college. Sometimes it was nice to be able to vent to people not in your department so it didn't get back to someone you didn't want it to get back to. That program also allowed me to become the representative for my department to the Women in Science program, so that was a great opportunity for leadership training.

So, once again it is clear that mentoring relationships, whether they are formed with individuals, through special programs created to promote student success, or facilitated by professional organizations, played extremely important roles in the success stories of our group of Native American Earth scientists. In addition to monetary resources and mentoring relationships, however, research experiences played an equally important role.

**Research Experience**

Another area which seemed to be critical for the development of Native American Earth scientists was practical experience working as a scientist (13/15, 87%). These experiences took the form of working in a departmental research lab (paid or volunteer), experience working outdoors, or summer research internships.

**Departmental research lab.**

Cindy, Erin and Hope recounted that their experiences working in a departmental research lab as undergraduates were critical turning points in their decisions of career path choices. For example, we have seen that when Cindy was hired to help a post-doc in a geochemistry lab the mentor-mentee relationship promoted a change in sub-fields in the student:

> And I found that the geochemistry profs, because I took this introduction to geochemistry course…really were encouraging. And one of the profs there, he actually hired me. He had a post-Doc that was working with him, and he hired me to assist her in the laboratory. And so I helped clean the laboratory, you know, you really had to be concerned about contaminants… But she was really nice, and she would explain to me what she was doing, and how my small part of running these columns for the isotope work she was working on, how it was going to contribute to the bigger study she was doing.

In another case Erin's work in a microbiology lab landed her a job running instruments in a geology lab, which lead to interest and a degree in geology:

> I was going to be an immunologist and a medical microbiologist, and when I went to get my Bachelor's Degree in microbiology they didn't have any medical degrees there. I wanted to get some lab experience and research experience. The only professors at [the university] were environmental scientists, so I volunteered in their labs and worked with some post docs and went on from there. I was volunteering in an environmental science lab that does microbiology. Then I got a job in the geology department running a lab…While I was doing that I took classes and got another degree in Geology and then stayed on that track.

Aside from jobs within departmental experimental labs, Paul and Deborah reported being awarded NASA Space Grants. The Space Grant program provided research experience, mentoring and money to students during the regular school

year. The Space Grant program afforded students opportunities to work in labs they might not otherwise be able to work at because it paid the student worker's wages, thereby allowing the faculty member to mentor a research assistant without having to provide funding. Deborah explained how the Space Grant program benefitted her:

> In my undergrad I received a NASA Space Grant in which I had some really good mentors. It was my first experience with doing research. I got to TA and do some research. That was really amazing. I got an internship to work on a telescope, because for a while I was flirting with the idea of being an astronomer, and through that internship I realized that I did not want to be an astronomer after seeing what they do on a day-in-day-out basis.

So one of the reasons that internships supported student success is that they allowed students to get a real feel for what being a scientist in a certain sub-field would be like. This was particularly important for students who may not have had any prior exposure to real scientific work. But opportunities to work in the outdoors also sparked student passions and took place outside of university settings.

**Experiences working outdoors.**

Opportunities found their way to students in many different ways. Here Flora described how a guest lecturer in her ethics class led to an internship in environmental education:

> Then when I was finishing up my undergraduate college degree there was someone who came to my class – it was an ethics class – and he talked about bioethics. He also happened to be closely associated with an environmental learning center. He said "Oh, we have an apprenticeship that we run at the learning center; maybe you should apply for it'. And I did… When I began working there, that was it for me. I knew that I wanted to get back into studying the Earth, I knew that I wanted to get back in to studying the environment, that set my pace right there.

For Flora, the experience she had during her internship shaped her future path back to the forgotten desires of her past and gave her the confidence she needed to pursue a degree in Earth Science. Oscar, dissatisfied with a potential career spent indoors, talked about his path to a degree in the Earth Sciences:

> I enrolled in social services, which was a three year program. It didn't give any options for working outdoors, though, so I started looking at career options and work environments. I was offered a summer internship through the tribe Natural Resources Management. It was a monetary opportunity. They gave a presentation at the college and I went and talked to them about it.

Once a student stepped down a path, often other opportunities presented themselves which allowed for the refinement of interests and ideas. The following summer, Oscar reported, "The Environmental Protection Agency gave me a summer internship at which I did field work, learned how to calibrate instruments, and got hands-on experience."

Six out of the fifteen (40%) students reported engaging in summer internships on or near tribal lands. Various government agencies were primarily responsible for the recruitment and supervision of these Native Earth scientists. In the following case Noah talked about a series of employment in the outdoors:

> Directly out of high school I went to work for the US Forest Service. I actually had to wait until I turned 18 to go to work. I think my grade was GS 1 Step 1. I was paid $2.08 an hour. Out of that they took my room and board. After two weeks my clear paycheck was $98. Then, between school stints I worked on the forest wide bridge crew for the [local] National Forest. Then after that I went to work for the Soil Conservation Service. It was sort of an internship program. I was recruited at the community college on the premise of working and then going to school and returning to work during the summertime and getting a degree in conservation or civil engineering.

Angela said, "The internships that I have done back home, a lot have to do with the National Park Service. The people there are very friendly." Barbara reported on her work classifying soils on her reservation:

> I did an internship with Natural Resource Conservation Service through a government grant. And I did work on different soils classification. We traveled all over the reservation looking at soils and plants, updating a 1968 survey.

So we see that Native college students were recruited to work outdoors during the summer by several federal agencies including the Environmental

Protection Agency (EPA), the US Department of Agriculture's Forest Service and Natural Resources Conservation Service, and National Park Service (NPS). In addition, Kathy discussed her experience as a high school student in the Bureau of Land Management (BLM) Youth Conservation Corps as being instrumental in her decision to pursue an Earth Science degree:

> I got a job in the Youth Conservation Core with the Bureau of Land Management. [We] lived at a camp outside of town where we did natural resource type projects. We built picnic tables for recreation sites, we built trails, we fixed recreational cabins, we did litter patrols. We did those types of outdoor projects, and I liked it. In that camp they also had a section where they taught us basic ecology and I really related to the science of it. I think that is where I got interested.

Several aspects of these outdoor working experience programs seemed particularly appealing to the students involved. One big advantage was that the youth were able to get paid for work close to home. Another aspect that the students seemed to like was the ability to work with their hands in an outdoor setting learning new skills. Although these particular experiences could not be considered research, they were important because they sparked interest in the future Earth scientists and showed students that they could make a career of working in the outdoors. In addition to these experiences working outdoors, summer research internships were important to Native Earth scientist success. The National Science Foundation provided funding for Research Experiences for Undergraduates (REU), which were summer research internships.

**Summer research internships.**

Summer is typically the season that researchers do most of their field work, and many researchers attempt to include undergraduate interns in their summer field season. Obtaining a REU grant is one way to pay for undergraduate research assistants. Research Experiences for Undergraduates are meant to get undergraduate students working on research in any of the fields supported by the National Science Foundation. Four out of the fifteen (27%) participants in this study stated that they had participated in an REU summer internship. Barbara related the following about her experience:

> I did a research program this last summer. It was a geomorphology based program where we were studying a stream intruding into a reservoir and the sediment was making it hard for [the] city to deliver clean water because of the particles. It was REU.

Another REU worked with soil sediment as well. The National Center for Earth Surface Dynamics actively recruited Native American students, and Hope described her experiences at the national center:

> I have been working at [the National Center for Earth-surface Dynamics] for the last two summers. That has been a big confidence booster, working at the lab. Just being involved with the program, just being able to present research and meet other students, trying to get them involved with the program.

So meeting other students in the Earth Sciences was a big part of the research experiences of these students. But these experiences did not just happen.

People made them happen. When Geneva was asked "*Did you encounter any people or programs that helped support you along the pathway?"* she explained:

> I have had some really good mentors. Those people have made a total difference. Diana Dalbotten was really great. I did an internship with her at National Center for Earth Surface Dynamics. She was great. She wanted to make sure that I had all the resources that I needed, that if there was anything she could do to help or facilitate anything, she did that. I was also a participant in the RESSES program. Susan Eriksson was really helpful. She paired me up with some mentors to explore different avenues that I could take. Whether I found out that I really didn't want to take those avenues, or I wanted to pursue them it was really helpful to know those things. Those people have especially been really, really super.

So when we look at what Native American Earth scientists who participated in this study identified as factors which supported their success, one thing is very clear. In addition to monetary *resources*, without which most of the participants would not have been able to attend college, the most important factor in promoting student success was the *relationships* they formed with other people. We see this theme in reports of mentor-mentee relationships as well as descriptions of research *experiences* both in the university lab and outdoor field settings. Also of vital importance was the experiential learning gained in both the laboratory and outdoor settings.

## Building Pathways

The list of barriers reported by Native American Earth Scientists was extensive and, at first glance, overwhelming. My intent with this work is to provide Earth scientists, Earth Science departments, and funding agencies with a data driven set of ideas for solutions garnered from the perspective of Native Earth scientists who had been through the process of obtaining a college degree. The most commonly discussed areas of support were resources, relationships, and experiences. With this in mind, to the question, *In what ways can Earth Science departments strengthen supports and minimize barriers that Native American students encounter when striving to attain a tertiary degree in Earth Science?,* I return to my data. For this question I incorporated the information relayed to me by five Native and five non-Native directors of programs designed to develop more Native American Earth scientists. Their information will provide a road map of how a support program might be developed and structured.

### The Difficulties of Getting Started

The first step in beginning collaboration with a neighboring tribal community is to be introduced by someone who is trusted by the community. One non-Native study participant, who is involved with a very large grant, discussed some of the issues she ran in to when she began to put together her program:

> It seems to me that there is a disconnect between the education community at the university level and the Native communities. How do you get over problems with distrust and build relationships? Universities think they are making a sincere effort to connect with the Native

community. But their idea of a sincere effort often means 'hey, we told this was available and you didn't come and do it with us.' It's not like understanding that there is a lot of suspicion and distrust of the university within the community. You have to build a relationship over time. You have to keep coming back even if nothing seems to happen.

First of all I got turned down by every tribal college in the state when I asked them if they wanted to be partners on our grant. That was a pretty discouraging process. Eventually our director called one of the professors [at the tribal college] and because he had connected research, he was interested in working with us as a PI. But even that took a lot of negotiating and difficulty. Then once he was part of our center he turned me over to [our K-12 tribal educational partners]. I would say it took us several *years* to the point that we could really work together well and trust each other and they could feel like I wasn't just there to take advantage of them.

You have to get introductions into the community. You can't just cold call. Even if you know somebody who knows somebody who knows somebody, and then you keep *trying*. If you get rebuffed by one person at the tribal college, it doesn't mean that the whole tribal college rebuffed you. So you might try some other people. You cannot go away just because the funding goes away, but you have to show people that you are willing to be a partner with them beyond funding as you all work together to get more funding. They are used to the idea that people just come in and

> get them to sign on and then they never hear anything about it again. I think there is this vision that we all have these piles of money that we are getting that we are not giving back to the community after they sign on, when what it probably means is that we didn't get the grant. You have to show some kind of commitment. You have to have a commitment to the relationship. I have been fortunate to have the ten-year NSF funding because it has allowed me to forge this kind of relationship. I think there should be more programs like that have this kind of funding that allow you to figure out what you are going to do after you run out of money. It took a good five years to get to the point where we could do something that NSF would even be impressed by. They waited and they waited and they waited, and eventually we got to the point where we said 'Now we have this, and it is looking much better than it did five years ago.'

Another non-Native Earth Science faculty member was recruited to participate in a new program aimed at encouraging Native American students to enter the Earth Science field because "Prior to participating in this I had taught at the [tribal] College for a semester, an introductory geology course." He talked about how he built the partnership between his university and the tribal college:

> My first contact was when I was contacted by the Dean of the [tribal] College to actually come up there and teach. [A member of the tribal college faculty] facilitated that experience. She did a really good job of just making sure that I felt comfortable coming up there. Subsequently, when we worked to develop partnerships with the [new program] we

> actually went to the Department of Natural Resources at [the tribe], and asked them to take us to sites where we might be able to do the kind of work that we wanted to do. So they were really cooperative all the way up to the Director of Forestry and the Director of the Department of Natural Resources. A couple of times the tribal chairman came by and sat down and talked to us. Then the students were talking to them about what they were learning too – that told me that there was a trade there. We were providing a service for the tribe and then the tribe was providing a service for us by allowing us to do research on this land.

These experiences led to this professor becoming further involved with local tribal colleges and their students through his affiliation with NASA Space Grant. He continued:

> I am also Director of our local NASA Space Grant affiliate. I have been able to get a small amount of funding to go out to the tribal colleges and visit with the students and faculty there and talk to them about ways we can increase student involvement in science in general. Of course NASA's idea is to train more engineers and scientists to participate in NASA activities but they are really concerned about increasing minority enrollment in NASA activities. For us up here the tribal areas are dominant minorities. So it is actually very effective. I was invited back to [the college where I was teaching]. I was invited back to [another college involved in the first program]. The place I had a little bit of trouble getting into was [another nearby tribal college]. I think it is mostly because they

were concerned that I was going to attract students to participate in our program when they were still looking for students to come to some of their summer programs. So I can understand that. Part of it is just the idea of convincing the students they need to come to a four-year institution after they have finished their two-year degree, and they need to go there with the mindset that will allow them to be successful there. That is my goal. I don't really care where they go, as long as they go somewhere.

These particular partnerships are between the tribal colleges and two-year degree granting institutions, like community colleges rather than universities. A university-tribal colleges partnership reported by a professor links three different tribal colleges within driving distance of the university. The partnership has Native students completing their basic courses at the tribal college and then transferring into a science major at the four-year institution. In addition to these partnerships, however, another partnership exists with a doctoral granting university in another state. So a pathway has been built from the tribal colleges through the four-year institution, and ultimately to the doctoral granting university. The Native Earth scientist from the doctoral granting institution explained the idea this way:

> We have a grant from National Science Foundation. It was a five year, $500,000 grant to develop research opportunities for Native American undergraduate students. We worked in [ a northern state] because that is where I am from, and that is the tribal community that I relate to. So we started our relationship by approaching faculty and staff at [the state

university], which is located in the central part of [the northern region of that state], and we targeted that school because around it are three of the largest reservations. We started our discussions at [the state university], and one of the gentlemen was from [one of the] Reservation and he thought it would be a great program to offer the students at [the tribal college]. So he opened the doors and helped us build a relationship between [our] University, and [tribal college] Reservation, and [the state university] which will allow them to go to their tribal college to get their two year degree, go to [the state university] to get their four year degree, and then come to [our university] in the geosciences to get their graduate degree. So we are building a step-wise program.

We do our research on the tribal land in concert with the local Department of Natural Resources, the Tribal DNR, the tribal elders in regards to what type of science they want us to look at and what type of science will be beneficial to their students. They were all very excited that we were geoscientists working with the land and not other types of science. They really liked that it had a geosciences base and we were training the students to become geoscientists. So the program itself is a three week long summer experience. We go up a week in May, a week in July, and a week in August. We go up and actually conduct field work. So we get hands-on field experience, we get hands-on lab experience, and they get numbers and data that they analyze. The students do all this, and we have field sites that we have had up there for five years so we compare

the data from year to year. At the culmination of the program we bring all the students to [our university] so they get to see a large research university and they get to hang out with the Native student population that we have [here].

We have about 14 Native American graduate students at [our university]. Typically we have one Native American graduate student in STEM every year, and in the last four years we have increased them to 14 or 15 a year. We are really excited about that. Our graduate students interact with the tribal college or [state university] students, and a great role model thing is being built. The [tribal college] students just spend a couple of days here. They present their research. They visit the campus. They get to meet the people here. And from that program we worked with 27 Native American undergraduate students in [a northern state]. Of those 27 one actually matriculated to [our university] and earned her Master's degree in biology, and we have had four of the students do summer-long research experiences here. They come here and work in a faculty member's lab all summer. They are still working on the research they did up on their reservation, but they did it from [our university].

We were trying to model for them what it would be like to be a graduate student, and show them that you can live at [our university]. They bring their families down a lot of times, and they see that it is doable. They can leave the reservation. They can leave their home and families for a period of time and then still bring it back to their

reservation. Of those four students who did summer research internships at [our university], all four are considering graduate school.

The project has been in effect for five years. We had hoped to have a lot more students attending grad school by now, but what we have found, and I think other people working on NSF grants in Native communities have found, it takes a lot of effort to build up a trusting relationship. So for the first two years we spent a lot of time talking about [our university] and why we were there. The main message we had to get across was that we weren't coming up there to steal the students away.

We don't want to go up there and take an eighteen year old student away from the tribal college. Our intent is to bring the kids down when they are ready to go to grad school, and *not* take them right out of high school on the reservation, and bring them to [our university] without the tools they need to be successful here.

A Native Earth Science faculty member took a different approach to spreading the word about Earth Science on her own reservation:

I had a grant. I visited 37 schools in [my state] one year. I don't want to put together a program that isn't what the people want or what they need. So I made a list of all the schools in [my state], and I hit every single school that was tribal, every BIA school, and every public school with high percentages of Indian students. Back then I was probably 25, 26 years old. And I think fairly fearless, because I wanted to make a difference. I wouldn't make any appointments. I would literally pull up, go into the

principal's office and say 'This is who I am, this is where I am from, and I would like to visit with our students today, might there be an opportunity for that?' And I would say that, at nearly all of those schools not only where they *shocked*, because I was the very first person they had ever seen from the [university] there, but they were more than willing to turn over classes for me to visit with.

The very first school I visited with was up on the border of [my state]. I went in and they brought all the high school students in for an assembly. And I had no PowerPoint, no posters, no nothing; just me and talking about the opportunity and what I would like to do. And I started talking to the young people about science, about engineering and how exciting it was. And as I looked at the students with their arms crossed, and they looking at me sometimes not with the most gracious appearance, one of the young men went 'Hey lady, the train stopped going through here years ago.' And that is when I realized that they defined engineering as being the engineer of a train.

I went 'Whoa, ok, this is going to require a lot more than just work. This is going to involve activities. I need them to *do* things, to practice things, to try things.'

So as I visited the schools I started taking around science kits. I had a star lab, which I received from NASA, with the [tribal] star knowledge globe in it. And what I started doing was setting these up in schools. I would do science night. I would set them up during parent-

teacher conferences. I pushed science fair really heavily. I started setting up at the mall, setting up the solar car, the mini-Indies, or the concrete canoe. I started bringing Indian families to the [university] campus, and entire *groups* of students to move through the labs. I actually had them underneath campus. We pulled back the tiled floor in the computer science lab and moved through the tunnels underneath campus so we could understand structural engineering, so they could see the 10,000 miles of fiber-optic cables. They could see the heating and ducting systems.

Probably the biggest piece was the [tribal] pow-wow allowed me to set up an entire room of geology tables highlighting all the rocks that come out of the [local area]. I was able to put out specimens collected from the Badlands, so dinosaur casts and those things. I set up the Star Lab. I think buy-in for the program came when it was community-driven; when the curriculum was going to be pretty much outlined by them.

I involved teachers from their schools in camps, because my thought was that, after bringing 125 students to camp every summer, their parents would drop them off at the beginning of summer and pick them up at the end, and around Christmas time they would call me and say, 'What went on during camp? Because now my child is doing a lot better.' So what I hear from a lot of folks is 'Indian parents aren't involved in their children's educational process'. Well, not if you don't invite them. So that was another piece. You can't just take a child away in the summer without working with the parents too. They want to know what is happening. They

want to know how to support. They want to know and understand what is happening with their young person. Well, you involve them then. You build them too.

Then, doing that – wow – the amount of information and knowledge that you get back as a program director, or someone designing one, is invaluable. And I hit a lot of conferences, and I visited with every single person I could. Not only letting them know the communities I was working in, but then highlighting what students were doing. I needed to create contemporary oral histories; stories to let folks know about what was happening, and then inviting them. You know, 'It would be great, Dr._____, if you would come out this summer and participate in a week of camp'. It was a lot of foot work.

With the elders, it was 'If this is going to allow us to revitalize our language, and help revitalize our culture, then we are willing to do it.' I think if I had gone and said 'We are just going to be teaching this, this, and this, and this is what I want you to do'…that wouldn't have gone anywhere. I think a big piece is your genuineness why you want to do it. I got that question a lot, and I got that question from students. 'What are you getting out of this?' 'Why are you doing this?' So it was really explaining and articulating to them what my motivation was.

A lot of times I would hear 'Well, you are getting paid a lot of money to do it'. So there is an outside self-motivation. I was pretty straight with students. 'I am definitely not getting rich doing this, it's not

financial, but in terms of coming to understand *myself*, and what we are doing in terms of trying to help our environment, yeah, I feel extremely wealthy'. Because you can't begin to protect or sustain what you don't know you have. So there is a large need to explain what the [mountains] are. What our history with the [mountains] is. What our future with the [mountains] will be. How *we* actually manage the land. How *we* manage entire herds of buffalo. Seeing how each of those things is related.

The process of developing a program may be very different for those who are not a member of the community, however, as this non-Native Earth scientist said:

When I proposed the program I talked to our multicultural program here, and we have a Native American advisory board. They come from five or six tribes around [the university]. We are right where [three states] all meet. So we have ten tribes within 200 miles. We have a representative body of five or six people who I talked to first, and they all said it sounded great. Once I got funded, I go on the road and talk to different tribal groups. I have been to [a reservation], a 300 mile drive, for me – twice. I go out to [a tribal college], I'll be up in [another city] in December. I go out to the [another tribal] community, and then other people involved in the program recruited [another tribe]. So we try to go out and talk to the people we are trying to encourage. We talk to the students, and I am a talker. In [one reservation] I talk to the Grade School, and in [the city] I will talk to entire families. The age range will be from 4 to 40.

> I go to summer camps, and there were some five year olds through high school students, and college age students. It takes a lot of time, but the school is very supportive of it. The multicultural association has a Native American member who is a gem. He is very accommodating; he is always willing to help. He gathers the students for AISES. He is the one who organized the group of ten who went to the national AISES conference. The multicultural group helps me generate numbers, because of course for NSF I have to continually report on how many students are coming in and things like that. So I do get a lot of support from the institution.

So there were many different ways that program directors began the process of developing and implementing programs, but several things are clear. In order to be effective, you must first gain access to the Native community, then form a relationship with the leadership of that community and involve them in determining what the needs of the community are. These relationships take time. Once a relationship has been formed, you must show commitment to the relationship by continuing to work with the community.

**Types of Programs**

The programs developed by the participants in this study varied greatly in scope and purpose. Some focus on building very structured, step-wise pathways to a particular institution. Others involved systematically contacting every elementary school on or near a particular nation. Still others contacted every tribal

college available regionally or even nationally. The size of a program, of course, depends on the amount of funding as well as the length of the grant.

**Science camps.**

One way that these program directors raised awareness of Earth Science as a field of study was through the design and implementation of science camps for Native youth. In this best case scenario a diversity director for a national project explains what can be accomplished when a center is funded by a ten year grant:

> We started in 2003 doing math and science camps with two different groups. We had high school students coming in [to the university] from all over the place, and they would do camp here in the summer for a week or two. It was heavy immersion into science and into traditional Native science.
>
> I also work with a Native American youth science program. These are camps for Native American K-12 students, usually middle school age. What we have been trying to do is bring scientists to the reservation. A constant at the camp is the teachers and the students. We bring in new students every year, but some of the students keep coming back. Some of the students have actually been in the camps since they were in second grade and are in middle school now, and some students who started in middle school have graduated and gone on to college. We bring a scientist in, and the teachers learn the topic that the scientist is going to be working on, whether it is earthquake structures or dam removal, and the teachers build a curriculum around that topic for the weekend. Our camps used to

happen four times a year – three weekends during the school year and a week and a half to two weeks in the summer. But, since we have gotten our new grant we have moved to having monthly camps from September to May.

With all of our programs we work in a communal way. My job as the director of diversity of my center is to handle the bureaucratic end of it, to write grants, to manage the budget, to think up new things we can do. But more important than that is I bring the science community to the reservation community. So, within the university I identify scientists who seem like they will be open to working in the Native community, interested in participating, and we go really slow. We introduce them to the teachers and elders first, ideally.

The best way to do it is to make sure that everybody has met the scientist well in advance before the scientist even goes to camp and give the teachers time to understand some of what the scientist is doing. For example, we had a woman from civil engineering who does a shake table that replicates earthquakes. We had her talk to our teachers and our staff about structures and what she does before she ever came to camp. The teachers devised some activities that the students could do at camp that were related to structures like simple bridge-building with macaroni.

Now it has been a little different with the new project, because there we have lake coring in January, February and March, and everybody knows that is what we will be doing. So we bring the lake core into camp,

> and we open the core in camp and that is the big hands-on activity. So we have been a little more rigorous about trying to figure out activities that go along with that that really relate to the history of [the study subject], the science of [the study subject], the history of the lakes, things like that that are much more tightly connected to [the study subject]. But we only do that in January, February and March. In the other months we have other activities.

According to the diversity director of this national project, one way to get involved with the community is by starting a science camp with Native youth. In this case, more than one camp was developed. One approach brings Native high school students to the university to work directly in a science environment for one or two weeks. The second approach involves intense collaboration with tribal members and area teachers and is heavily invested in the place where the research is being conducted, the reservation. This second approach involves developing an intergenerational model of instruction, which maps well onto most traditional indigenous instructional styles. One Native Earth scientist tells us about her experiences running a summer science camp and how she ended up changing the approach to suit her students:

> When I came to [the university] I was the director of a grant program. That was a six-week immersion where 125 high school students came to the campus for a six week bridge. It was everything from chemistry to calculus, English composition, physics. For the first two years I did that. I was as unhappy as the 125 students, because there we were in four walled

classes, trying to learn material that wasn't really fun looking over the [mountains], where every single one of us wanted to be. And as I looked at, literally, students wanting to be out there, I was thinking 'I want to be out there too'. It wasn't working, and I had to accept and acknowledge that you cannot bridge someone's knowledge of chemistry in six weeks. Not enough where they can be successful in a college chemistry course.

So I wrote back to NSF, and I received partial funding for an OEDG – an Opportunity for Enhancing Diversity in the Geosciences. And that allowed me to move out of the classroom and take them into the field. That allowed me to focus on what everyone was interested in. For one, our sacred sites, because a lot of the [local tribal members] that live in [the state] don't necessarily have the resources vehicle-wise, even sometimes financial, even to the most sacred place in all of our lands. It was also an opportunity to partner with local elders, so they became my PhD professors. Instead of trying to teach chemistry, it was teaching ethnobotany, ethnogeology, ethnoastronomy. Communicating through oral histories, what our formal understandings of the science were.

What I found, and what our formal evaluators found, is that if we could increase the self-esteem and the self-confidence as well as the feeling of being Indian, understanding our purpose and our story, you could set students free to achieve whatever they set their minds to. So instead of trying to literally harass them about chemistry; helping them understand the reason why they are here.

> It was through our geosciences summer field experience in the [mountains] our own children came to understand our relationship to the land. That our oral histories are exactly that; an oral history of our interaction with the land, not fairytale, not folklore. All the terms that are used to describe our oral histories are really negligent in the actual definition. Not only did elders see that, but high school students, middle school students, elementary students, and I had parents. So you could take your parents, your grandma, your grandpa, older brother, your sister with you to camp too.
>
> All of a sudden the knowledge of the group started to come out. So you might have a six-year-old say 'yeah, I know that is peppermint because my grandma such and such said such and such'. And they did it in a family context of 25 each week, and it was like 'wow. See? you already know this stuff.' How do you connect science terminology, science understanding, within an oral history frame? Every time we revisit those sites, all that knowledge comes back.

This model illustrates an ethnocentric learning camp which is rooted in the place and utilizes multigenerational learning. The advantage of this type of model is that the awareness of Earth Science as a field of study can be increased on a community level rather than just a single generational (e.g. high school students) level. This type of experience, however, requires a solid relationship with community elders and other knowledge bearers and may be difficult to achieve as an outsider to the community.

**Science fairs.**

Another way to get involved with the local community at the K-12 level is to help organize, and provide mentors and judges for, a local science fair. Student participation in a science fair can lead to further participation in AISES national conferences or regional science fairs, as one program director stated:

> We have organized a science fair that we do every year at the tribal college. I think that is morphing into a regional science fair this year, but the idea was to have a science fair that was just Native kids so that the kids would be encouraged to participate. We've had an average of fifty to sixty kids a year enrolling projects in our science fair. The kids who do well we try to support as many as we can to send to the national AISES science fair.

**Regional AISES and SACNAS chapter alliances.**

Another way to promote the development of Earth scientists is to begin or become involved in a local AISES or SACNAS chapter at the college level. In this example, faculty from several colleges worked together to create a larger network of Native STEM students:

> I work with undergraduates too. With the Native American undergraduate students in [a northern state] we started a STEM Alliance, part of Louis Stokes Alliance for Minority Participation. Since Native students identify so much with their AISES chapter, a lot of students see that as an organizing focus. We started to bring together AISES chapters in the state, finding out which colleges in the alliance had an AISES chapter. If they

didn't have an AISES chapter, finding out if they used to have one and who was the AISES advisor and trying to get them to support organizing a chapter. If they did have a chapter we tried to bring them into more activity.

We were able to support some students to go to AISES national or regional meetings. We try to bring them together once or twice a year so they would know each other and form a larger group than just at their own university. We have been working with the students that way for three or four years. We have had some successes with that, and some where we feel it is hard to get the students organized because they are busy with other things. So it is not always easy to hold a meeting. We are still working to see how to make that group effective and support students at the undergraduate level.

**Research experiences.**

Another way to get involved is to provide research experiences for Native students. In this case, the program director began a Research Experience for Undergraduates program in conjunction with nearby tribal college partners.

I also have an undergraduate Research Experience for Undergraduates. We just resubmitted a new research proposal for that where we are going to do a research experience for undergraduate students on sustainable land and water management. If we get funded for that we will do it with [two tribal colleges] and it will be Native focused. Specifically looking at issues of land and water management, which we think are pertinent to the Native

> community and would draw more interest from Native American students into the geosciences.

Once relationships with tribal partners are established the opportunity exists to collaborate with tribal college faculty members on other projects. As networks of faculty collaborators grow so, too, do opportunities for their students. One program director explained:

> We have been working with [a tribal college]. We have our faculty to faculty program through our center. What that has tried to do since we started it four years ago was to try to involve faculty from minority colleges into the research of our center, and to try to get them to be part of our center as an associated PI so that they will form a relationship with our partner institutions that will last longer than our center and can help improve diversity in our colleges and strengthen participation by minorities in the sciences in general. Recently we have been extremely happy that we have found a Native American geologist at a tribal college…and he has become a partner investigator on our grant. The role we played with him is advisory to try to help institute this [new] program at [his tribal college] which just got accepted, so we are very pleased with that. So that is what we have been doing at the upper level.

There are many ways that Earth scientists and Earth Science departments can become involved in promoting Earth Science as both a field of study and a viable career option. Among the programs that are working for the participants of this study are building clearly marked, step-wise pathways from institution to

institution, science camps, school visits, organizing science fairs, forming AISES or SACNAS chapters and alliances, developing research programs with local tribal colleges, and building collaborative relationships with tribal college faculty members. The process is not easy or quick, however, so you must anticipate that there will be problems and setbacks. I asked the study participants what some of the barriers they encountered while starting programs were, and here is what they had to say.

**Problems**

Any time you build something new you are bound to encounter dips and boulders in the road. Building a new program is no exception. The program directors I interviewed reported having problems with the length of short-term grants, efforts to build trust, communication with both partners and students, recruiting students, dispersing money to students in a timely manner, and overcoming doubts about failure. In this first quotation this program director explained that a five-year grant did not give her adequate time to both build necessary relationships and provide concrete results for funding agencies:

> We were funded by Geoscience Education at the National Science Foundation. It was a five year program, and we got $500,000. We are just now ending our funding, so we are submitting another grant to continue the partnership. We really need a ten year grant, and I think it is something that NSF is beginning to realize. They are beginning to realize that when you work in established communities like tribal reservations a big chunk of the beginning part of the grant is spent building up relationships. You

> can't just go into a Native community and think you are going to make a change in five years. It really needs to be a longer process.

Another program director talked about the fear he had that his NSF program goals would not be met. He was also concerned about failure in the face of NSF requirements:

> I do get quite a bit of funding from NSF, so I was a little worried about failure. Could I, in fact, generate the numbers that NSF wanted? Now we are three years into the program, and I think we can officially declare it a success. The institution loves it. The institution is very supportive of Native American students, and in the three years that the program has been running…we are now designated a Native American Serving Institution. We are above 15% Native American enrollment.

One program director spoke of the need to build trust as a huge priority for her program, and offers some suggestions to Earth scientists who wish to make research on tribal lands a part of their program:

> The biggest barrier, or challenge, was to build up the trust. We tried to be transparent in what we were doing, and of course honest. Never forging ahead on our own with what we were doing. Everything was in collaboration with the tribal Department of Natural Resources, or the elders, or the faculty at the tribal college. We always made sure that, for example, we do not go to our research site without having students from that community go with us. We don't just go up and look at the site. We always explain what we are doing with the data and with the samples, and

> how everything was going to be managed. I would say that is a very different paradigm for a lot of people who do research. A lot of researchers would say, 'This is my research. This is my field site. I am going to do what I want'. But when you are working in a tribal community you have to realize that it is their land, and their field site, and you can't just forge ahead and do whatever you want; you have to be respectful. Things happen at a different pace when you are working with a big group of people. So that is very important, you have to be respectful of the land and who you are working with.

Part of building trust is having open lines of communication. One program director found that communicating with people on the reservation was often problematic. Internet connections, which many of us take for granted, often do not work on reservations and cell phones also do not always function due to the remote locations of many reservation lands. This program director found that having a separate personal Facebook account for program participants produced good communication results:

> In the community we work in, communication is very important, and how you communicate with students is important. I have found over the last five years that the way that the students respond to me the quickest is through Facebook. They never respond to my e-mails. A lot of time in the community, especially if it is a remote community, they don't have good internet connection, so they will lose their internet connection for a week. So trying to send e-mails isn't always good. Trying to call on the cell

> phone isn't always good, because sometimes they are in an area that doesn't get good cell phone coverage. But Facebook, I don't know if it is on their phone or they are more connected to that, but if I send out a message on Facebook I always get a response within a few hours. I have my own personal page with students on there that I use. We do have a Facebook page, but I don't think we use it. It is more me sending messages, and then I always include all the [program] scholars and send it directly to them. But there are only about 15 of us in the group. Even the faculty members I can nudge along through Facebook because we can start a conversation. But they actually answer. If I send an e-mail sometimes people forget to hit reply all, then you have a string of e-mails; so for my students I have found that Facebook works the best.

Another program director found that the institutional barriers set up by the funding agency with regard to money distribution were problematic. Most of the Native American students taking part in these programs do not have the financial resources to pay for even incidentals such as food when they attend conferences, and federal regulations do not allow programs to give students money in advance. In addition, even though students do get paid a stipend for their internships, it often takes six weeks for those paychecks to be processed.

> One of the barriers that we've had, which would be good for NSF to hear, is getting money to the students. Other program directors have the same issues. When we go somewhere we can pay for hotel and airfare, but we can't give them food money. You have to reimburse them at the end. If

> you give them a scholarship it is going to be *taxed* at some point. If you talk to any of my [program] scholars that is going to be a big challenge. We have fought with that for five years; what is the best way to get these students the money? They get paid for doing our summer internships, but it takes six weeks to get them any money. It is federal government rules and regulations on how you can disperse money, but I think that is one of the number one barriers for student participation. Particularly students from underrepresented groups and particularly the Native students we are working with.

Program directors also sometimes have misgivings about their role in the programs they have helped to create. This particular non-Native program director expressed having to overcome his misgivings before beginning his outreach program:

> The intimidating thing for me is I had never stepped foot in a reservation school to talk about [university] programs, so there was a little fear of the unknown for me, too. Could I be a credible recruiting individual? Again, I don't know much about it, but I have heard that there are White guys going to the reservation all the time spreading crap and I didn't want to be that guy. So I was a little bit nervous about how things would go. Luckily for me, the [Native] students that were already at [my university] jumped right on board, and they have been a big help with recruiting, and interacting with new students, and peer mentorship is just great.

People who have been actively working on broadening the participation of Native Americans into the Earth Sciences have provided some good working plans here on how this issue can begin to be addressed. Fundamental to the solution is the creation of trust relationships between Native communities and Earth science professionals. These relationships take time to build, but positive results can be achieved. Some of the problems which have been encountered by the program directors in this study include the mismatch between the lengths of time needed to cultivate new working relationships and the time constraints inherent in grant funded projects, problems in communicating with both students and community leaders, problems recruiting students due to their familial obligations and transportation constraints, dispersing of monies within federal guidelines to students who cannot afford to pay for meals and other incidentals, and overcoming doubts.

## Chapter 5

### Discussion and Conclusion

At the beginning of this work I claimed that I was going to get at the institutional structures in place which reflect a Western perspective, demonstrate that they exist, and show how they affect indigenous students. According to the National Center for Women & Information Technology (2011), *institutional barriers* are policies, procedures, or situations that systematically disadvantage certain groups of people. The barriers which were reported in the data included factors which impeded a college degree, factors which impeded the decision to study Earth Science, and factors which impeded progress within an Earth Science degree program.

### Factors Which Impede Obtaining a College Degree

Factors which impede obtaining a college degree included financial barriers, pressures from familial obligations, and health issues. The financial barriers discussed by participants in this study were issues of the price of tuition, books, and living expenses required to be paid when pursuing a college degree. College is expensive. Even middle class families have a hard time paying for college (Biden, 2009). Most indigenous students do not come from middle class families (Figures 9 & 10). Without financial aid resources 80 percent of the participants of my study would not have been able to afford a college degree. That is an institutional barrier.

The Native American Earth scientists in this study (8/15, 53%) also identified pressures from familial obligations as being a barrier to their education.

Even though familial pressure is not absent in other groups, some familial obligations, such as needing to go home for weeks or even a month at a time for funerals or other ceremonial obligations, posed problems for some members of this group. This can be considered an institutional barrier because faculty may not be aware of the customs and traditions of their students, and problems stemming from these absences can ensue. In other cases students had families which they needed to rush home for, precluding them from taking advantage of programs and opportunities incompatible with the lifestyles of students who are also working parents. This is also an institutional barrier which particularly affects students who have children.

Some of the health and mental health issues which arose (8/15; 53%), like those associated with feelings that a student "wasn't good enough" to be a graduate student in her Earth Science department, or the depression and feelings of helplessness which occurred when work piled up too high are also not strictly conditions of being Native American, but may also be considered institutional barriers if the departmental environment is particularly hostile to women, as was reported here by a third of the women interviewed. As we saw, however, a good advisor or other support person can be instrumental in staving off or helping a student deal with both physical and mental health issues.

**Factors Which Impede the Decision to Study Earth Science**

Factors which impeded the decision to study Earth Science included unfamiliarity with geoscience as a field of study and career choice, the uninviting nature of Earth Science as a profession, and curriculum that is irrelevant to the

practical needs of Native communities or courses which are inaccessible geographically. Eighty percent of the participants talked about geoscience not being known in tribal communities as either a field of study or a career choice. Although this barrier cannot be considered an institutional factor at the university level of instruction, it has most certainly been exacerbated by the presence of an institutional barrier at the elementary and high school levels. Only two out of the fifteen (13%) participants reported having any kind of Earth Science instruction at either the elementary or high school levels. If a student has never heard of geoscience, she will never be a geoscientist. We need to do a better job of getting the word out about Earth Science as a career option, and issuing an invitation for others to join us while we are at it.

The Native Americans who I talked to repeatedly spoke of the need for Earth Science knowledge to be practical in solving the problems found in their homelands today. We have seen that many of the problems of grave concern to indigenous peoples have to do with clean water and remediating the effects of natural resource extraction on their land. In addition, invasive species, such as the earthworms studied by one program, have caused changes to the land and are of concern. Overall, there is a pressing need for research which will help mitigate some of the needs of the community.

Earth scientists can begin to address some of these issues by engaging in *community-inspired research.* Community-inspired research stems from the needs of a community and is developed in collaboration with them. It is designed to be useful in meeting the needs of the community, and should include using members

of the community to help gather and analyze data. These community members could be students or potential students who might be persuaded to pursue an Earth Science degree.

A need also exists for degrees in Earth Science to include practical skills which can be translated to meaningful careers on Native lands. In many cases, an Earth Science degree is not appealing because it does not appear to be practical, and course names are unintelligible to non-geologists. In addition, large segments of the Native population do not have access to Earth Science courses near their homes. The geographic location of many members of the Native community is definitely a result of the effects of colonialism, as indigenous peoples were pushed farther and farther from their ancestral lands to make way for White civilization. This distance to academic institutions can be considered an institutional barrier, as universities are traditionally built near White population centers. To believe that a Native student will jump at the chance to move away to a strange land to begin studying Earth Science seems a stretch. Perhaps we can do a better job of getting interesting, practical, experientially-based courses closer to Native homes in rural communities.

Another institutional barrier which was discussed by Native faculty members is what was termed by one as "Ivory Tower turf wars". In Ivory Tower turf wars, departments do not give transferable university credit to students who take courses which were designed with the indigenous student in mind. In the example given in this study, the class was termed an "extension" class, and only applicable to an "Indigenous Studies" certificate. The argument here is that the

courses are “watered down” or “not rigorous enough” for university credit. In reality, this institutional barrier makes it more complicated for Native students to attain degrees in Earth Science because, even if they become interested in pursuing an Earth Science degree and decided to move to a university to attain it, they would have to re-take the courses over again for university credit, wasting the precious resources of time and money.

**Factors Which Impede Progress Imbedded in Earth Science Programs**

Factors which impede progress that were embedded in Earth Science programs included educational preparation, academic information and counseling, inter-departmental relationships, and the prevalence of a Western scientific perspective in the classroom to the exclusion of all other perspectives. Barriers which stem from educational preparation, specifically math, chemistry, and physics, can definitely be traced to an institutional root cause of colonialism. The educational system on Native lands has been subjugated, and is under colonial control still today. This is one of the issues of self-determination which Native peoples are fighting for.

Beyond the issues of imposing a culturally irrelevant educational system on indigenous peoples, of greater issue is the education students on and near the reservation are receiving. Participants have told us how they were labeled as future “factory workers” and not allowed to take college preparatory course work, they have told us how constant frustration with failure in mathematics in the past lead them to believe they could not “do” mathematics. In fact, of all the educational barriers Native peoples faced, the one most often expressed was that

of inadequate preparation in mathematics (11/15; 73%). But it wasn't because they couldn't "do" math – most eventually took Calculus I and Calculus II and passed – but it was the quality and unavailability of mathematics instruction that was the institutional barrier in this case, at all levels of the educational system.

Access to good quality instruction at high school levels provided additional institutional barriers as students struggled to pass mathematics and science courses once they became necessary in their university Earth Science program. Perhaps the biggest barrier this problem poses is the spiraling effect that bad grades in Calculus and Chemistry courses have on a student's grade point average, subjecting them to academic probation and making them ineligible for funding; another institutional barrier.

Native American students are very likely to be first generation college students. In this study seventy three percent (11/15) of the Native Earth scientists who participated were first generation college students, the other four had one or more parents with a Bachelor's degree. No one had a parent with a graduate degree. As a result, students reported difficulty navigating the academic system. Problems arose when students took too many courses during a single semester, or had questions about graduate school. Non-traditional students reported having to seek out information on graduate programs and other opportunities, as opposed to being approached by faculty and other potential mentors, and some felt that student counseling programs in place at the university were not designed to accommodate their needs. Since over half of the Native Earth scientists interviewed were non-traditional students the failure of both Earth Science

departments and university counseling systems to provide appropriate guidance for older students was problematic for this group of participants, and can be considered an additional institutional barrier that had to be dealt with.

Another barrier to student success reported by the participants of this study was no clear pathway to discovery of the type of Earth Science sub-field that might best suit the student. In addition, an overwhelming percentage (14/15; 93%) expressed a desire to work on environmental geology issues. In many cases, particularly for re-entry students who were non-traditional in age, desire to heal the land was a motivating factor in their decision to return to school. In many cases students found that the career they thought they preparing for, where they would be able to use the skills learned to solve environmental problems back home, did not line up with the focus or program of the department. This institutional barrier was a cause of frustration for several of the participants. In other instances a student found her passion through a summer internship, only to find that the amount of additional time and money required to pursue that field of study put it out of reach as a career goal.

Intradepartmental relationships also posed barriers to the success of some students, particularly those who were non-traditional students (53%) or women (80%). Problems with intradepartmental relationships included tension between students in different sub-fields of Earth Science within the department, non-supportive departmental professors, an environment which was hostile to women, and resistance to a student's presence and contributions due to her age. Conflicts between sub-fields were especially detrimental when the advisor of a student was

in a new, non-traditional field which the other members of the department did not support the inclusion of. This is most certainly an institutional barrier at the departmental level, one which can, and must, be addressed in Earth Science departments if they are sincere in their desire to welcome underrepresented groups into the Earth Science fold. New groups of researchers bring new ideas and new ways of thinking. This is a good thing. But the departmental atmosphere must be such that the ideas and the people have room to grow because they are different, not in spite of it. If there are problems with sub-groups in a department, at the very least there needs to be a discreet system set up where the problems can be ferreted out and addressed.

One thing that was of concern to a large number of participants in the study was the non-supportive demeanor of many faculty members within the department. Although this barrier was not reported to be due to the fact that the participants were Native American, its existence should be of concern to all Earth Science faculty members. Elements of hostility which were cited included lack of interest in undergraduate students, lack of understanding for working student, and conflicts negotiating research agendas. Lack of interest in undergraduate students in Earth Science departments can be seen as an institutional barrier. Given that one of the major tasks of a faculty member in the sciences is to produce research, it is understandable the professors would give more attention to their graduate students, who are helping them to get their research done, than undergraduate students, who are not. As scientists we know that the way to get ahead in a science program is to align oneself early and frequently with scientists and get

involved in their research to show that we are really serious about science, right? However, given that the Native students in this study did not come from families with scientists in their background, they would not have known that. This is yet another institutional barrier, one which can be rectified at the departmental level. In order to overcome this institutional barrier, it is imperative that faculty members make the effort to reach out and recruit *all* Earth Science undergraduate students into their labs.

Several participants talked about having barriers put in their way during the proposal defense stage of their graduate program. This can be considered an institutional barrier when roadblocks are applied to some students and not to others. It is also one of the reasons that participants felt that the Earth Sciences were not welcoming to them as students. If we want to attract more people into the Earth Sciences we need to move from an exclusionary model to an inclusionary model. With this suggestion I am not saying that we relax the rigor of the degree, but rather turn the process of advancing to candidacy from one that is antagonistic and designed to break a candidate to one which is synergistic, where the committee helps the candidate to develop the best research proposal possible, as is the case in other fields.

One third of the Native American women interviewed reported harassment by faculty members in Earth Science departments because they were women, not because they were Native Americans. In several cases the harassment was so intense that it affected the student's relationships with other students and jeopardized their ability to complete their program of study. In two cases the

situation was so intolerable that the student moved either to another department or another university. The culture within Earth Science departments can be hostile for women, particularly for women who are older than traditional students. In addition, many Native women are respected leaders within their community and have grown up in the outdoors, often performing the same tasks that men do in White rural societies. On several occasions the Native women I interviewed expressed surprise to find themselves in a field that was considered to be non-traditional for women because they knew they were capable of doing anything a man could. To be discriminated against in this manner is also an institutional barrier that members of Earth Science departments can be vigilant against.

The final barrier which was reported by twelve out of the fifteen participants (80%) was that of Earth Science knowledge being taught from a Western perspective only. This can definitely be considered an institutional barrier which affects Native students and is directly related to the effects of colonialism. It is important to note here that no one expected a sole focus on indigenous perspectives in their science classes, however, participants in this study found the complete failure to even acknowledge any indigenous accomplishments reinforced their feelings of subjugation due to colonization. Even in areas with a high concentration of Native students or in places that were surrounded by Native peoples there was never an acknowledgement of the local peoples or their knowledge of the land. In some cases Native students were put on the spot to act as spokesperson for all Native people, a role they were uncomfortable with.

Part of the problem with looking at things from a Western perspective which was particularly troubling to Native students was the tendency of science to break knowledge into small pieces for examination, but then fail to put them back together into a more holistic picture of what is really happening in nature. Eleven out of the fifteen participants (73%) described themselves as thinking holistically when approaching problems. This tendency to teach science from a fragmented (silo) perspective is an institutional barrier that is part and partial of our current educational system and a direct effect of colonialism. Traditional Native teaching tends to be holistic, experiential, and hands-on (Battiste, 2002). Earth Science can be taught this way at the university level, but often is not.

**Factors Which Support Native Students Studying Earth Science**

The three main supports reported by Native Earth scientists which helped them to be successful in their Earth Science programs included financial assistance, mentors and mentoring, and research experiences. Eleven out of the fifteen (73%) of the participants volunteered that they received assistance in the form of scholarships or fellowships from sources outside the university. Of these awards, the most often reported source was the American Indian Science and Engineering Society (AISES). This organization, along with others, was touted as being critical for the success of many of the Native participants interviewed. Earth Science departments who are serious in their commitment to broadening the participation of Native Americans in the Earth Sciences could do much to encourage Native students by becoming involved, or even hosting, a local chapter of this organization within their department.

The support most often discussed by Native Earth scientists (14/15, 93%), however, was the need for a good mentor and mentoring. The mentoring received took several different forms. Among them were specific individual mentors, special mentoring programs, or mentoring networks encountered through participation in organizations. Individual mentors made a huge difference in the academic success stories of twelve out of fifteen (80%) of the study participants. Individual mentors took the form of high school teachers, community college instructors, student support services personnel, graduate students, post-docs, and professors. In all the interviews one idea came through very clearly: *it only takes one*.

It only takes one person to make the difference between a successful student experience and one that ends in failure to complete a degree. In some cases the mentor went to bat for a student during confrontations with other faculty members, but in other cases the professor simply invited the student over to have dinner with his family. Or allowed undergraduate students to pop by the office and talk. Or put the student to work in his lab. The most important feature of these relationships seems to be that the students simply have someone they can come and talk to when they have questions or the going gets tough. This is something we can all make an effort to do more of, and the participants of this study told us it makes a world of difference to them.

Special mentoring programs were also responsible for students' success. These programs usually ran outside of the department, however, and brought students together from different fields. The McNair Scholars program, the TRiO

umbrella of student services and the Louis Stokes Alliances for Minority Participation (LSAMP) programs were all instrumental in the success of many of the students interviewed. These programs are mainly focused on helping first-generation college students succeed, and provide road-maps to navigate school systems. They are not usually focused on providing road maps to get students through Earth Science programs, but some agencies do have opportunities to write grants specifically for science focused programs, as was done with the Alaska Native Science and Engineering Program (ANSEP).

Another special place that should be mentioned here is the American Indian Center that many universities have on campus. Several of our participants found communion in these centers and the support of the staff there invaluable to the success of their academic journey, particularly in the undergraduate stage. If your department is looking to broaden the participation of Native Americans in Earth Science, you might want to investigate the presence of an American Indian Center there and form a relationship with the director and staff.

Professional organizations such as AISES, SACNAS, Association for Women Geoscientists (AWG) and Women in Science (WIS) also made a difference in the success stories of these Native Earth scientists. If there are no chapters at your university, and frequently there are not, looking into starting a chapter might be a good opportunity to draw students. Often these organizations have school chapters within a department, but students outside that particular department may not be aware that they exist.

Research experiences also motivated success in Native Earth scientists. Several different types of research experiences were described by participants in this study. Departmental research, experience working outdoors, and summer research internships all contributed to student success. In some cases, working in a departmental lab provided students with both career path direction and individual mentorship. Oftentimes undergraduate research assistants can be written into research grant proposals, giving students money, research experience, and a place to call home and put their books. The importance of this last piece cannot be stressed enough. Although it may seems inconsequential, that feeling of belonging and having a safe place within the department to go each day can make a huge difference in the life of a student. One research program which was mentioned several times and can be of benefit to both the faculty researcher and the student is the Space Grant program. Beyond just a place to put their books, research experiences in departmental labs give students an opportunity to investigate the different sub-fields within geology, allowing them to narrow their interests.

Experiences working outdoors were reported as being one of the catalysts for a student deciding on Earth Science as a career path. Often these experiences are paid summer jobs near a student's home. Other times a summer job with the National Park Service or other federal agency gives students a new direction as they realize that there are careers that allow them to work in the outdoors, and that they enjoy it.

Summer research internships were also mentioned as a valuable experience by some Native Earth scientists. In several cases, a summer research internship allowed a student to discover that she either did or did not want to pursue a particular field of study in graduate school. Another value of summer research internships is that the student is exposed to the idea that graduate school exists and that they can go if they would like to pursue that pathway. For these Native students, summer research experiences provided a way to develop valuable relationships with both their mentors and other students similar to themselves.

**Building Pathways**

Pathways need to be built if we wish to broaden the participation of Native Americans in the Earth Sciences. The program directors in this study gave us some suggestions on how we can get started.

1. Check the condition of your heart. Why do you want to become involved with this community?
2. Get introduced to the community you wish to work with by someone they know and trust.
3. Be persistent. No from one person does not necessarily mean no from everyone.
4. Talk to the community about what their needs are BUT be prepared to let your ideas go if the community is not interested.
5. Make sure that all parties know exactly what you can (will) and cannot (will not) do.
6. Be committed to the relationship even when the funding runs out.

7. Building trust relationships takes time. Usually there are few results the first five years. This must be a long term commitment.

**Building Programs**

The participants in this study provided us with several examples of things we can do to get involved:

1. Build a step wise program which originates at tribal schools, goes through a 4-year college, and ends at a doctoral degree granting institution.
2. Visit schools and community events and bring hands-on experiences to the community. Educate the community on how to become an Earth scientist.
3. Plan summer Science and Math camps involving the community, university, local teachers and students, science educators, and elders. Make them ethnocentric, rooted in place, and multigenerational.
4. Promote and develop science fairs in the community and local school system.
5. Sponsor SACNAS or AISES chapters in your department.
6. Begin a Research Experience for Undergraduates (REU) in conjunction with tribal college partners.

**Potential Problems**

The participants in this study also provided us with a list of problems that they encountered in building programs and working with communities:

1. The length of federal grant money programs is often not long enough to provide results. Participants tell us that you do not begin to see results

until at least five years into the grant. For real results the grant needs to be ten years in duration.

2. Communication with both partners and students is paramount, but often difficult due to connectivity problems in rural areas and on reservations.
3. Recruiting students to programs is often slow and difficult. Many students have work or familial obligations which do not allow them to participate in standard programs.
4. Dispersing monies under current federal guidelines is often difficult. There are things that cannot be paid for in advance, yet students do not have the funds to pay in advance and then be reimbursed.

**Forging Relationships with Communities**

One thing Earth Science departments can do to promote a goodwill presence in the community is to require all students to perform service to the community as part of their Earth Science degree requirements. Many tribal colleges require students to have interactions with younger community members, and these programs could be used as a model. Currently a service component is required in many non-tribal university programs for graduation, but I have not seen it required in Earth Science programs. Requiring Earth Science students to do community service would begin to change the mindset of the discipline from one in which science is done for the sake of science (prevalent now) to one in which science is done for the sake of service to society.

**Strengthening Earth Science Departments**

Earth scientists and Earth Science departments are becoming increasingly alarmed at the lack of students wishing to pursue advanced degrees in Earth Science fields. One way to increase student numbers is to increase participation of women and minority students who do not regularly choose Earth Science as a field of study. Among these underrepresented groups are Indigenous peoples, worldwide.

The small change in thinking from "Science for the sake of science" to "Science for the sake of society" would not only encourage more Indigenous students and other minorities to participate in Earth Sciences, but would also encourage women into the field, as it has been found that women generally desire to do science to help people. The propensity to want to help has been suggested as one of the reasons that the life sciences have been much more successful at recruiting and retaining women and minority students than the physical sciences and engineering have (including geology).

Ways to give back to the community could include acting as tutors for students who are struggling with gatekeeper subjects such as Calculus and Physics, or engaging local underrepresented minority students at the elementary or high school level. Geology students need not act as teachers and present lessons, although bringing along a hands-on lesson or two would provide valuable experiences for students, but rather it would be beneficial to have them take on the role of goodwill ambassadors. As ambassadors, budding geologists could sharpen their public speaking skills while providing information on careers in the

geosciences. In addition, student ambassadors could provide travel logs and narration of their research projects and give minority students and Indigenous community members the opportunity to interact with actual scientists.

But the students are not the only university members who need to connect with local tribal members. *Every Earth Science department in the country that is located near a reservation or other tribal land should appoint a faculty member to be its liaison with local tribal members.* This professor should be sympathetic to the need to increase minority participation in the Earth Sciences, and be willing to learn tribal social customs and protocols. (S)he should go to the tribal leaders and ask what the problems are that a Native Earth Scientist might be able to help the community with. Then (s)he should be able to go back to the department *and have her voice heard* as an advocate for the community. (S)he should also be given credit for this work within academia when tenure review time rolls around. And the work should be *valued* by the geoscience community at large as essential to the survival of both the discipline, and the planet.

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# APPENDIX A

# INSTITUTIONAL REVIEW BOARD APPROVAL

ASU ARIZONA STATE UNIVERSITY
RESEARCH AND ECONOMIC AFFAIRS

Office of Research Integrity and Assurance

| | |
|---|---|
| **To:** | Dale Baker<br>EDB |
| **From:** | Mark Roosa, Chair<br>Soc Beh IRB |
| **Date:** | 04/28/2010 |
| **Committee Action:** | **Exemption Granted** |
| **IRB Action Date:** | 04/28/2010 |
| **IRB Protocol #:** | 1004005017 |
| **Study Title:** | Factors which impede and/ or support the progress of Native American students interested in pursu Earth or environmental sciences. |

The above-referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.101(b)(2) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

You should retain a copy of this letter for your records.

# APPENDIX B

## PROGRAMS AND ORGANIZATIONS

## American Indian Science and Engineering Society (AISES)

The mission of the American Indian Science and Engineering Society (AISES) is to substantially increase the representation of American Indian and Alaskan Natives in engineering, science and other related technology disciplines.

Since 1977, AISES has worked to remove barriers to fuller representation and participation in the science, technology, engineering, and math (STEM) disciplines among Native people – as students, professionals, mentors, and leaders.

### The Work of AISES

Through the quality and reach of its programs, the longevity and the devoted commitment of its "family," AISES is the undisputed leader in STEM education in Indian Country. Members from over 200 Native Nations are represented within AISES, and AISES enjoys the support and partnership of corporate, government, academic, and Tribal decision-makers.

As students, AISES members strive to succeed at the highest level. As professionals, they create dynamic cohesion between indigenous ways of knowing and the evolving technological challenges of today's world.

These challenges are multifaceted and complex, including harnessing sustainable energy, ensuring supplies of clean water, balancing the needs of an ever-complex world with the mandates of environmental stewardship, dealing with health challenges, and making the best of technological innovations.

http://www.aises.org/

**Louis Stokes Alliance for Minority Participation (LSAMP)**

The Louis Stokes Alliances for Minority Participation (LSAMP) program is one of a sequence of four NSF programs which seek to build productive capacity and output within institutions with significant enrollments of minority populations underrepresented within science, technology, engineering, and mathematics (STEM) professionals. The other three NSF programs are Alliances for Graduate Education and the Professoriate (AGEP), Centers for Research Excellence in Science and Technology (CREST), and Historically Black Colleges and Universities Undergraduate Program (HBCU-UP). The ultimate goal of these efforts is to increase the number of minorities contributing to advancing the frontiers of research and education in STEM fields. LSAMP is a multi-disciplinary comprehensive program. It is designed to increase substantially the quality and quantity of students receiving baccalaureate degrees in STEM fields and well prepared for either doctoral study or professional practice in STEM fields normally supported by NSF. The LSAMP program encourages the formation of alliances among leaders throughout academia, government, industry, and other organizations. The LSAMP program supports comprehensive attention to those processes and factors that promote baccalaureate attainment, preparation for graduate study, and preparation for successful careers by students within alliances. These alliances may include partners drawn from among two- and four-year higher education institutions, businesses and industries, national research laboratories, local, state, and Federal agencies.

http://www.nsf.gov/pubs/2003/nsf03520/nsf03520.htm

**The Alaska Native Science & Engineering Program (ANSEP)**

ANSEP is a longitudinal model that works with students from the time they are in middle school all the way through to the PhD. ANSEP increases university recruitment and retention rates through hands-on middle and high school outreach initiatives, rigorous summer bridging programs, focused academic learning communities, organized student cohorts, networks of peer and professional mentors, community-based learning, professional internships and undergraduate and graduate research projects.

Our objective is to effect a systemic change in the hiring patterns of Indigenous Americans in the fields of science, technology, engineering and mathematics (STEM) by increasing the number of individuals on a career path to leadership in STEM fields.

We are working with approximately 700 students in Alaska. 400 of these are in grades six through twelve, 300 are university undergraduates, and 21 are graduate students.

http://www.ansep.net/

## Alliances for Graduate Education and the Professoriate (AGEP)

### What is AGEP?

The Alliance for Graduate Education and the Professoriate (AGEP) seeks to join together universities and colleges in the common mission of increasing the number of underrepresented minority students earning PhDs and positioning minority students to become leaders in science, technology, engineering and mathematics (STEM) fields.

Each AGEP alliance employs creative administrative strategies, develops infrastructure, and engages in substantive partnerships with nondoctoral-granting institutions (many minority-serving institutions) to enhance recruitment, retention, and advancement

http://www.agep.us/

**Student to Academic Professoriate for American Indians (SAPAI)**

**Description:** Student to Academic Professoriate for American Indians (SAPAI) is a project funded by the National Science Foundation to increase the rates of degree completion for American Indian graduate students in Science, Technology, Engineering and Mathematics (STEM). It also aims to increase the representation of American Indian and Alaska Native (AIAN) scholars in STEM faculties at Tribal Colleges and Universities (TCUs). This will be accomplished using three steps.

* Step 1- a six week writing workshop/retreat, will enhance degree completion.

* Step 2- consists of a second workshop to provide participants with tools and skills to flourish as TCU faculty members.

* Step 3- offers a one-year apprenticeship for Step-up scholars at a TCU.

http://www.pathwaystoscience.org/programhub.asp?sort=AGE-UMontana-SAPAI

## Federal TRIO Programs:

The Federal TRIO Programs are educational opportunity outreach programs designed to motivate and support students from disadvantaged backgrounds. TRIO includes six outreach and support programs targeted to serve and assist low-income, first-generation college students, and students with disabilities to progress through the academic pipeline from middle school to postbaccalaureate programs. TRIO also includes a training program for directors and staff of TRIO projects and a dissemination partnership program to encourage the replication or adaptation of successful practices of TRIO projects at institutions and agencies that do not have TRIO grants.

**TRIO PROGRAMS**

Educational Opportunity Centers

- Ronald E. McNair Postbaccalaureate Achievement
- Student Support Services
- Talent Search
- Training Program for Federal TRIO Programs Staff
- Upward Bound

  Prepares high school students and veterans for success in postsecondary education. Types of projects include Regular, Veterans and Math and Science Centers. Regular project services include a summer instructional component; instruction in subjects including mathematics through pre-

calculus, laboratory science, and foreign language; mentoring programs; counseling; and exposure to cultural events.

- Upward Bound Math-Science
- Veterans Upward Bound

**Ronald E. McNair Postbaccalaureate Achievement Program:**

The McNair Scholars Program is a federal TRIO program funded at 194 institutions across the United States and Puerto Rico by the U.S. Department of Education. It is designed to prepare undergraduate students for doctoral studies through involvement in research and other scholarly activities. McNair participants are either first-generation college students with financial need, or members of a group that is traditionally underrepresented in graduate education and have demonstrated strong academic potential. The goal of the McNair Scholars Program is to increase graduate degree awards for students from underrepresented segments of society.

http://mcnairscholars.com/

**Society for the Advancement of Chicanos and Native Americans in Science**

SACNAS is a society of scientists dedicated to advancing Hispanics/Chicanos and Native Americans in science. We are a national nonprofit organization of individuals and organizations interested in quality science, technology, engineering, and mathematics (STEM) research, teaching, leadership, and policy.

**Mission**

SACNAS fosters the success of Hispanic/Chicano and Native American scientists—from college students to professionals—to attain advanced degrees, careers, and positions of leadership in science.

**Goals/Outcomes**

1. To increase the number of Hispanics/Chicanos and Native Americans with advanced degrees in science and the motivation to be leaders.
2. To increase the number of Hispanics/Chicanos and Native Americans in science research, leadership, and teaching careers at all levels
3. To increase governmental commitment to advancing Hispanics/Chicanos and Native Americans in science resulting in increased resources, elimination of barriers, and greater equity.

**Values**

1. Inclusive of ethnicities, cultures, and scientific disciplines
2. Focused on having a real impact through our purpose and mission
3. Committed to standards of excellence in science and education
4. Fully mindful of the importance of students' K-12 experience
5. Devoted to full engagement of our members in our work http://sacnas.org/

## National Space Grant College and Fellowship Program

NASA initiated the National Space Grant College and Fellowship Program, also known as Space Grant, in 1989. Space Grant is a national network of colleges and universities. These institutions are working to expand opportunities for Americans to understand and participate in NASA's aeronautics and space projects by supporting and enhancing science and engineering education, research and public outreach efforts. The Space Grant national network includes over 850 affiliates from universities, colleges, industry, museums, science centers, and state and local agencies. These affiliates belong to one of 52 consortia in all 50 states, the District of Columbia and the Commonwealth of Puerto Rico.

The 52 consortia fund fellowships and scholarships for students pursuing careers in science, mathematics, engineering and technology, or STEM, as well as curriculum enhancement and faculty development. Member colleges and universities also administer pre-college and public service education projects in their states.

http://www.nasa.gov/offices/education/programs/national/spacegrant/home/index.html

**Research Experience in Solid Earth Science for Students (RESESS)**

RESESS is an undergraduate summer internship program in the Earth sciences based in Boulder, Colorado, that is dedicated to increasing diversity in the geosciences. The goal of the RESESS Internship program is to increase the number of students from minority groups that are underrepresented in the geosciences relative to their proportions in the general population.

RESESS encourages applications from individuals who are members of a group that is historically underrepresented in the Earth sciences, including students who are Black or African American, American Indian or Native Pacific Islanders, Hispanic or Latinos, and others.

We introduce students to scientific research, prepare students for graduate school, and provide support and encouragement as students build skills and confidence. Students experience an authentic research experience and are encouraged to consider graduate school with an eye to a career in science, whether that is in research, teaching, or industry. Students can participate for up to three years, depending on when they enter the program.

http://www.resess.unavco.org/resess.html

**Research Experience for Undergraduates (REU)**

The Research Experiences for Undergraduates (REU) program supports active research participation by undergraduate students in any of the areas of research funded by the National Science Foundation. REU projects involve students in meaningful ways in ongoing research programs or in research projects specifically designed for the REU program. This solicitation features two mechanisms for support of student research: (1) *REU Sites* are based on independent proposals to initiate and conduct projects that engage a number of students in research. REU Sites may be based in a single discipline or academic department, or on interdisciplinary or multi-department research opportunities with a coherent intellectual theme. Proposals with an international dimension are welcome. A partnership with the Department of Defense supports REU Sites in DoD-relevant research areas. (2) *REU Supplements* may be requested for ongoing NSF-funded research projects or may be included as a component of proposals for new or renewal NSF grants or cooperative agreements.

http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5517&from=fund