Xoa:dau to *Maunkaui:* Integrating Indigenous Knowledge into an Undergraduate Earth Systems Science Course

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ABSTRACT

Very few Native American students pursue careers in the geosciences. To address this national problem, several units at the University of Oklahoma are implementing a geoscience "pipeline" program that is designed to increase the number of Native American students entering geoscience disciplines. One of the program's strategies includes the development of an undergraduate course called 'Earth Systems of the Southern Great Plains.' The course focuses on geoscience topics that relate to the southern plains (particularly Oklahoma), emphasizes "sense of place," integrates indigenous knowledge and geoscience content, makes use of Kiowa stories and metaphors, and uses Native American Art as a vehicle of learning. Students in the course are required to put living indigenous philosophies into practice through teaching activities and the construction of geoscience models using everyday materials. The course is designed to highlight the integrated nature of Earth processes, elicit students' experiences through exploration of case studies illustrating links between indigenous knowledge and Earth processes, and demonstrate the process of practicing science. Formative student evaluations are providing useful information and the course is evolving. Preliminary assessment results suggest that integrating Native American culture, art, and geoscience content is a successful approach.

INTRODUCTION

The course 'Earth Systems on the Southern Great Plains' is an introductory Earth System Science course that integrates indigenous knowledge into the geosciences and uses Native American art as a vehicle of learning. The course is part of a project at the University of Oklahoma (OU) entitled "Diversity in Geosciences: Development of a 'Pipeline' for Native American Students," the objective is to develop opportunities for Native American students to participate in geoscience education and research.

Data from the National Science Foundation (Huntoon and Lane, 2007), indicate that certain groups, including Native Americans (Riggs and Semken, 2001), are underrepresented in geosciences at the undergraduate and graduate levels. This is certainly the case in the geoscience-related colleges (The College of Atmospheric and Geographic Sciences or CGS) and The College of Earth and Energy or CEE at the University of Oklahoma). In Oklahoma, 17-18% of the population is Native American. Yet in 2006 only 3% of the students in both colleges were Native American. Native American students comprise only 7.1% of the total student population at OU. Projections indicate that in the next 5 years the numbers of Native American High School students in Oklahoma will increase by approximately 20-25% (Western Interstate Commission for Higher Education, 2003). The opportunity exists to increase the number of Native Americans in the geosciences, provide rewarding educational and career opportunities for the students, make important connections with families and communities, and contribute to the growing science and technology workforce in Oklahoma and surrounding regions.

The introductory undergraduate course uses a multidisciplinary approach with a global perspective and builds on the "connectedness with the planet" that is a part of Native American beliefs (Cajete, 2000). The course is designed to; 1) cover selected topics in greater detail than in most introductory courses, while highlighting the integrated nature of Earth processes, 2) elicit students' experiences through exploration of case studies illustrating links between indigenous knowledge and Earth processes, and 3) demonstrate the process of practicing science. The course focuses on geoscience topics that relate to the southern plains (particularly Oklahoma) and emphasize "sense of place." A "sense of place" refers to the set of meanings of and attachments to places held by individuals and/or by groups and that is important in their cultural and educational philosophies -- in this case, of Native Americans (Semken, 2005). Native American stories, metaphors, and images are also important aspects of the course.

In this paper we describe how indigenous knowledge and Native American art are incorporated into the course. We also discuss the use of Kiowa stories and metaphors, and how our undergraduate students put living indigenous philosophies into practice through teaching activities and the construction of geoscience models using everyday materials.

BACKGROUND

Many factors contribute to the lack of participation in the geosciences by American Indian and Alaska Native students including the distinct lack of professional mentors (practitioners and academics) in the geosciences and differences in worldviews between scientists and traditional indigenous practitioners (Zappo, 1998; Mullens, 2001; Aikenhead, 1996; Nelson-Barber and Estrin, 1995; Deloria and Wildcat, 2001; Semken, 2005).

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For example, one ecological observation argues that Western culture is based on control, manipulation, planning, modeling, power and competition, and the Navajo way is based on cooperation and reciprocation (Grinde and Johansen, 1995). This suggests that there is a divide between the meanings and values engrained within the natural sciences and indigenous knowledge (Grinde and Johansen, 1995; Semken, 2005). This view creates a dichotomy between indigenous knowledge on the one hand and science on the other. Furthermore, Native American communities are often conceptualized as being either traditional or non-traditional. Dichotomies may help explain the philosophical divides between Native American thought and Western science. However, one scholar warns that dichotomies unintentionally present indigenous knowledge as a closed-system, archaic and frozen in time, while science is a dynamic, progressive open-system that thrives on changes and adaptations (Agrawal, 1995). In reality, both systems are open and susceptible to transformations. The level of openness may vary among Native American tribes across space on a regional, community, or individual scale. This may be especially true for Oklahoma which is home to over 40 Native American tribes, and is a landscape of blended ethnicity. New research on this topic is needed before a more substantial socio-spatial theory can be presented. One can argue that indigenous knowledge and the geosciences are dynamic and ever-changing. This is not merely a practical statement, but is rather based on the living indigenous philosophy of relatedness.

A common philosophical idea among Native Americans is the notion that everything within the cosmos is interrelated (Cajete, 2000); everything changes. For instance, "The meaning of the Lakota aphorism, "mitakuye oyasin" (we are all related), is shared by all Indigenous people. Its shared meaning stems from the fact that it is a guiding principle of the spiritual ecology held by every tribe in its perception of nature" (Cajete, 2000, p. 178). This includes rocks, rivers, trees, animals, sea creatures, people, sun, moon, and stars (Williamson and Farrer, 1992). The interconnectivity among all natural things is often referred to as the "Sacred Circle." This philosophy can be found in Native American art, stories, literature, and environmental awareness (e.g., Palmer and Palmer, 2009; Miller, 1992; Hughes, 1983; Lake-Thom, 1997). Similar philosophical views are shared in the geosciences, which strive to develop an understanding of how our planet functions in response to interactions between land, oceans, and the atmosphere.

A number of teachers and scholars in the geosciences have successfully integrated indigenous or ethnoscientific knowledge into course curricula and programs (e.g., Dubiel et al., 1997; Semken and Morgan, 1997; Murray, 1997; Aikenhead, 2001; Semken, 2005; Gibson and Puniwai, 2006; Hanks et al., 2007; Riggs et al., 2007). Many of these programs emphasize placed-based curricula (e.g., Riggs, 2005; Semken, 2005). For example, Navajo worldviews have been successfully woven into a place-based geoscience course at Arizona State University (Semken, 2005). Semken's Navajo students are connected or related to the landforms on the Colorado Plateau. Because there is familiarity, there is engagement between the students and professor. The learning environment is reciprocal because wisdom is embedded in places and landforms, constantly reminding and teaching life lessons (Semken, 2005; Basso, 1996). This suggests that landforms, creeks, rivers, and the sky are not passive objects, but rather related, active participants in the nurturing of intellectual development among indigenous peoples.

Less work involved the integration of indigenous knowledge with atmospheric science concepts and processes. However, the book *Weather, Nature, Culture* (Strauss and Orlove, 2003) provides some insights on folklore, unusual weather events, and visual representations, though not entirely from the perspective of native peoples in the Americas.

A number of other institutions and professors have incorporated indigenous knowledge into programs and courses that are related to geosciences. For example, faculty and administrators at Native American institutions such as Kansas' Haskell Indian Nations University recognize that a holistic approach to understanding the Earth as a system is an important part of students' curricula in forestry and environmental science (Sloan and Welton, 1997). Holistic approaches to managing natural resources can be found on tribal lands owned by the Menomonee and Yakima tribes (McCorquodale et al., 1997). An example of this would be sustainable forest management practices on Menomonee land (Lemons, et. al 1997).

Research on Native American students suggest they are 1) more skilled in visual and 'hands on' tasks than in verbal communication, 2) more oriented toward observation than verbal instruction, 3) are better able to handle spatial than sequential activities, and 4) more comfortable with group learning activities than with individual activities (e.g., Anderson and Adams, 1992; Moore, 1988). To address this we incorporated active learning strategies (e.g., Bonwell and Eison, 1991; Johnson et al., 1998; Bean, 1993; Fink, 2003) in the course. We focused on teaching/learning activities that can promote three components of holistic active learning: (a) gaining information and ideas, (b) engaging in doing or observing experiences, and (c) engaging in reflective dialogue, about the learning process as well as about the subject (Fink, 2003). This has the advantage of incorporating the positive educational activities that are contained in both passive and active learning. For example, as described below, in addition to listening to lectures, the students in the course experienced the geosciences curriculum by observing art, listening to stories, problem solving in groups, learning by teaching, debates, class discussions, and dialogue with other students and the instructors.

Indigenous Knowledge and the Native American Art Connection

Native American art is used as a vehicle of learning and helps to integrate indigenous knowledge into the course. The classroom presentation is designed to demonstrate to Native American students that their deeply rooted ancestral heritage of involvement with land and with all aspects of nature is of great importance. This

involves teaching about particular tribal aesthetics, the strong creativity of their ancestors, (appropriate specific tribes based on student class population are presented), and the ingenious creativity of contemporary artists. The respect for nature and the idea of solidarity with the earth is revealed in the arts of the multiple tribal groups.

Educational outcomes from the presentations include; 1) Students will become aware of the significance of the early art works of the ancestors and how the work constantly refers to aspects of nature including, wind, sun, earth, agriculture, astronomy, animals and man, 2) This will also include a prominent view of contemporary art which follows much of the same themes as ancestral art, 3) Students will develop an understanding of the significance of the "geosciences" and their relationship to all life seen through Native American cosmology, arts and how this is applied in contemporary university studies.

Pre-Contact Native American and Indigenous peoples, from the Inuit of the Canadian Arctic through all areas of the United States, into Mexico, Central and South America, studied geology, astronomy, climate and seasonal changes, and all aspects of our planet. Survival of peoples depended on their assimilation of this ethnoscientific knowledge, and how it affected their ability to gather, hunt, eventually cultivate, and to establish towns and cities from prehistory to the Twentieth Century. These people gave great respect to volcanoes, mountains, rivers and streams (Plog, 2002). Certain aspects of the land were deemed sacred; stones were associated with events in the mythic past; trees sacrificed themselves for canoes or houses; and particular resources were gifts from the earth. Intensive and complex cosmologies and accompanying ceremonies were developed within each tribal group to celebrate and give thanks for the seasons and the wealth of the lands.

In prehistory, people portrayed scenes of human, animal and climatic activity in areas of the North America and throughout Mesoamerica, Central and South America (e.g., Fiedel, 1992). Incised images in stone and paintings proliferated throughout the Americas. Carvings of human images, flora and fauna indicated the importance of the human relationship with the land. Early representational paintings and drawings of lightning, rain, clouds, mountains, volcanoes and other landforms suggest acute observations of nature (e.g., Marshall 2002). In addition, these peoples continually worked to keep all of nature's forces in balance with themselves. This balance between the land and human beings appears in the visual arts, in architecture, pottery, painting, the fiber arts, ceremonials and songs.

Native American arts reflect the forms of earth and sky. The ancient pueblos in the North American Southwest pay homage to the forms and materials of the rugged cliffs and mountain shapes surrounding the areas where they were constructed (Morgan, 1994). In some instances the Pueblos remain seamlessly joined in a harmony of reflected shape. Circular forms, taken from the moon or sun, become a sacred medicine wheel, or the pattern for community dances (sometimes called the round dance), which in turn represents the circular repetition of all life in a non-linear society.

Landforms and raw materials of the American Southwest continually influenced Native artistic designs and the myriad, resultant art forms (I am Here, 1989). In New Mexico and Arizona, the land offers up to the makers various types of clay that is worked into beautiful and stunning pottery (Peterson, 1998). The ancient pueblo people made special pots to inter with the dead, and to trade. Geometric forms in abstract patterns adorn this pottery. Hard-edge, abstract painting with iconography is found on the pottery of the Hohokam, Mogollon and the Anasazi. Similar ancient patterns concerning rain, clouds, and lightning are employed and understood by contemporary artists and their audience (Jacka and Jacka, 1994).

Particular types of stones represented royalty or wealth and were carved in the likeness of gods, important people and animals. Knowledge of stone introduced the development of lapidary workshops and created a massive trade system throughout the Americas. Turquoise mined in Nevada, Arizona, New Mexico and Colorado resulted in long distance trade with numerous tribes. The prehistoric Hopi mined coal and the Zuni created a system of small, carved stones, which brought good fortune when carried by their owners. Currently, Zuni "fetishes" are sought by tribal members and art collectors (e.g., Rodee and Ostler, 1990). These miniature images are carved in a wide variety of stone including alabaster, turquoise, serpentine, jet, and fluorite among others.

Paints were made throughout the Americas by crushing rocks, using plants and adding binders such as bear fat or other ingredients to make the paint adhere to surfaces. Pictographs (rock or cave paintings) are found in many areas of the United States (Schaafsma, 1980). Many Kiva wall frescos are found in New Mexico and Arizona. Native arts continue to hold a strong place in the cultural fabric of the United States and especially in the Southwest. In contemporary Native American art, themes and iconography are borrowed from the past to present contemporary views of land, people and animals. These become representations.

Finally, Native American art and storytelling are often used as "a method of telling the stories of those people whose experiences are not often told" (Solórzano and Yosso, 2002). This is often referred to as countering or counter-storytelling, placing the subject within the context of indigenous culture and society. One Native American counter-art project entitled 'Native Views: Influences of modern culture,' features a variety of art pieces that combine indigenous philosophies with materials produced by American popular culture (Arttrain USA, 2004). The art in this project also counters and challenges the notion of traditional Native American societies. Other examples of countering that pertain to the geosciences include counter mapping (Avataq Cultural Institute, 1991), bioregional mapping (Aberley, 1993), and multimedia geographic information systems (Palmer, 2009).

Metaphors and Science

We use the idea of Native Science as a metaphor for incorporating elements of indigenous knowledge and

philosophy, with the hope that such action fosters creative participation, among our students, with the natural world in both theory and practice (Cajete, 2000). An objective of the course is to get students to think creatively about the world around them and engage with geoscience topics that are otherwise inaccessible. Geoscience is inaccessible to many students because they are unaware of what the discipline actually covers and what geoscientists actually do. Native American storytellers actively seek participation between their audiences and the earth. This is one reason we turn to Native American cultures that engage with the earth and sky in their philosophies. We use Native American views as a new bridge for transferring knowledge to students.

How might we go about presenting the geosciences through the lenses of Native American cultures? One approach is to use North American Indian images, stories, metaphors, and philosophies to present science concepts. Students need to see science as something that is not mysterious, but accessible. Cultural representations aid in the process of teaching difficult geoscience concepts. North American Indian cultures stress that nature is not simply a collection of objects, but rather a dynamic ever-flowing river of creation inseparable from the earth and sky. Metaphors are used to explain earth cycle processes and the meaning of places.

Intellectually, metaphors are bridges that aid people in understanding a complex world. Metaphors aid humans in interpreting the world around them and can serve to strengthen meaning and works particularly well during times of major change, alleged disorder, and disconnection between places (Popper and Popper, 1999). Geographer Anne Buttimer writes, "A treasure of insight can be unlocked via metaphorical rather than literal or rational thinking ... because metaphor performs a poetic as well as conservative function in ordinary language, preserving as well as creating knowledge about actual and potential connections between different realms of reality" (Buttimer, 1993, p. 78). Metaphors reveal values and show how one views the world. Metaphors create and clarify meaning, and a shared memory or experience of places and regions.

Some scholars believe that the only hope of reconnecting to place lies in using stories and vibrant language: "Our task, rather, is that of taking up the written word, with all its potency, and patiently, carefully, writing language back into the land. Our craft is that of releasing the budded, earthly intelligence of our words, freeing them to respond to the speech of the things themselves ... It is the practice of spinning stories that have the rhythm and lilt of the local landscape, tales for the tongue that want to be told, again and again, sliding off the digital screen and slipping off the lettered page to inhabit these coastal forests, those desert canyons, those whispering grasslands and valleys and swamps" (Abram 1996, p. 273-274). Contemporary industrial society is inundated by text and information. Thus, the use of metaphors are primarily associated with literature and written forms of communication. Metaphors are also an integral component of oral traditions and storytelling (Cajete, 2000; Morton and Gawboy, 2000; Palmer and Palmer, 2009).

Science educator Gregory Cajete stated that "the metaphoric mind remains the foundation of Native Science" (Cajete, 2000, p. 28). Metaphors are equally important in Western science as well. Meteorologists often refer to frontal boundaries associated with low pressure systems as 'troughs.' Thunderstorm clouds are described as 'anvils.' The mechanization of scientific metaphors is noted and discussed in the literature as sometimes being an inappropriate representation of nature as viewed by some Native American people (Aikenhead, 1997; Semken, 2005). Interestingly, meteorologists that observe severe thunderstorms in the field often describe thunderstorms using non-mechanical metaphors such as the 'bear's cage' (within the domain of a mesocyclonic rotation) or describing moisture inflow areas of thunderstorms as 'tails.'

Metaphors are not necessarily literary tools. They can also be used as a vehicle for knowledge transfer in relation to oral stories, images, and living indigenous philosophies. Cajete continues by adding that, "Because its processes are tied to creativity, perception, image, physical sense, and intuition, the metaphoric mind reveals itself through abstract symbols, visual/spatial reasoning, sound, kinesthetic expression and various forms of ecological and integrative thinking [expressed]…in story, art, community, dance, song, ritual, music, astronomical knowledge, and technologies such as hunting, fishing, farming, or healing" (Cajete, 2000, p. 30-31).

Some culturally conservative members of Native American communities may believe that using stories within the context of science is inappropriate, believing that such action takes the stories out of context. As stated earlier in the background section, however, beliefs and practices vary from one Native American group to the next; region to region; community to community; individual to individual. One of the faculty, who is of Kiowa descent, uses the old Kiowa stories in different ways (Palmer and Palmer, 2009). The stories are important cultural foundations, but even more important is the process of storytelling and the journeys that storytelling leads the students and professors on. Storytelling is a vehicle for carrying-on living indigenous philosophies. Native American stories like the sciences are open-systems. As with Native American artists, Native American academic scholars are likely to counter and challenge traditional notions of indigenity in their work. Likewise, the geosciences are not protected from the complex and contradictory impacts of encounters. Societies are ever-changing and only momentarily stable (Latour, 2005).

COURSE DESCRIPTION

Three faculty teach the course Dr. R. Douglas Elmore (geology/geophysics), Dr. Kevin Kloesel (meteorology), and Dr. Mark Palmer (geography). Dr. Mary Jo Watson, an Art Historian, participates in some classes and provides presentations which integrate Native American art into the course. The course is not an example of tag team teaching. The three regular professors attend all lectures and participate in the class discussions. This is

important because it facilitates drawing connections between topics and ideas. The students also point out this is a very positive part of the course; they appreciate the interaction between the faculty and between the faculty and students. The course fulfills a natural science general education requirement at the University of Oklahoma.

An "integrationist" approach (Murray, 1997) is used in the course, where Native American views are given respect but are interpreted in terms of Western scientific theories. For example, one way we will integrate indigenous knowledge into the course is to learn how and why many tribes view nature as a great-connected circle. All of the content ultimately ties into larger earth cycle processes.

After a brief introduction, we start the course with the section on the Earth. We begin our discussions with a consideration of the external and internal systems, pointing out the connection with Father Sky and Mother Earth in Navaho beliefs (e.g., Semken, 2005). The hydrologic and tectonic cycles are discussed as well as the unifying themes (e.g., 2nd Law of Thermodynamics). This is followed by a discussion of Matter, Minerals, and Rocks. As part of this segment of the course, Dr. Watson uses pictures and samples to illustrate and discuss Native American jewelry in North America. As a connection with her presentation on Native American Jewelry, the geologic origin of turquoise and jade are discussed. Native American paintings are also used to illustrate landforms. A great sensitivity toward landscape and the principle forms from which the earth is made is very apparent in Native Americans appreciation and cosmological appropriating of various aspects of nature. Mountains with caves become the place of emergence, mountains of special shapes become sacred, stones, rocks and natural minerals enter into the artistic language of Native tribes depending on the availability of natural resources. Following a discussion of igneous processes and the rock cycle, the external processes such as weathering/erosion, rivers, and deltas, are discussed. Case studies on the hazards of living on a flood plain in Oklahoma and on the "Control of Nature" which is focused on the Mississippi River Delta and "Should (will) the Mississippi Change its Course?" This is followed by a section on water resources (Water-Too much, Too little, Too dirty) with a focus on groundwater in Oklahoma. For example, we discussed ground water depletion and asked the students to come up with viable solutions. Finally, we discuss geologic time and contrast Native American and Western Views of time.

Content focusing on atmospheric science is introduced mid-semester and focuses on the climatology and weather of Oklahoma, droughts, floods, thunderstorms, and tornadoes. Much of this lends itself well to visual images found in Native American art and photographs which are integrated into the lectures. For example, thunderstorms are presented to students as images of clouds and images found in Native American stories like the thunderbird. The students must think about the information embedded in both the cloud and thunderbird images. One of the assignments given to the students involved the interpretation of a stunning supercell thunderstorm photograph. The students were asked, "What does this look like to you?" This exercise encouraged students to think about and (re)imagine thunderstorm clouds in a different way.

The final section of the course focuses on the geographic synthesis of the geological and meteorological content. Storytelling and metaphors are used as analytical tools and integrated into the geoscience content. Many of the metaphorical examples are found in Kiowa tribal stories and associated with historical events. The Silver Horn pictorial calendar is another indigenous knowledge system used in the course. The calendar contains images with embedded information. Information in the pictorial calendars is local and particular. For this reason students must listen carefully to the stories told to them in order to interpret the images and tie to geoscience topics. We assigned individual case studies for the students to read. Among the stories are an analysis of the 'Buffalo Commons' controversy, the geography of the Texas Panhandle, Palo Duro Canyon, and the reversibility or irreversibility of human and natural systems. Students read the assignments and were given real world problems to solve. Students then presented their arguments to the class. In other words, we required the students to put their knowledge of the geosciences and metaphors into practice.

Some examples of Kiowa stories that explain natural phenomena are spread throughout the course. These include the story of tree rock (Devil's Tower and the Big Dipper), Mankauii (tornadoes), and the legend of snapping turtle (ground water). These stories are well-known and published within the Doris Duke oral history transcripts available to the general public (Koplowitz, 1993).

Tree Rock (*Xoa:dau*) - Devils Tower

The story of the Seven Sisters (Great Dipper) is significant among several Plains Indians nations in North America. Tree Rock or the story concerning the structure of Devil's Tower in northeastern Wyoming is a very old Kiowa story and one of numerous stories making up what some identify as the Kiowa Origin Cycle (Palmer and Palmer, 2009). The Kiowa account of the story tells of events that took place at the base of *Xoa:dau* (Rock Tree) a long time ago. The story also describes how seven girls coaxed another girl into playing a bear. The girl had magical powers. She turned into a bear. She chased the seven girls to a large tree stump that spoke to them and told them to jump on top. The tree grew and carried the girls up into the heavens where they became the Big Dipper or as the Kiowa call them, the Star Girls. As the tree was growing the bear clawed the sides of the tree creating vertical columns or lines. By dreaming up the story of the children playing bear and rising up into the heavens on a growing rock becoming the Big Dipper, the Kiowas came to terms with something extraordinary and unforgettable in their human history (giving meaning to the place known as Rock Tree or Devil's Tower).

The vertical columns of igneous rock make up Devil's Tower and the Kiowa storytellers explained that the columns resulted from the tearing claws of a bear. Several of the students in the course suggested that the Tower was

a volcanic plug, the correct interpretation. As part of the discussion, we examined aerial photographs looking for other evidence of igneous rocks such lava flows.

Tónà:qàut (Snapping Turtle) – Groundwater

Another Kiowa story is embedded within the Wichita Mountains and the adjacent limestone hills to the north in Oklahoma. A north to south pass traverses through the hills called *Á:jàungà* (Timber Gap). There is an old story about this Kiowa site. It is an interesting story told by the late Kiowa elder David Apekaum, but is much too long to include here. *Tónà:qàut* could flow through the ground from the *Á:jàungà* spring, north to the Washita River. We tied some of the *Tónà:qàut* story in with our discussion of groundwater aquifers and springs. *Á:jàungà* springs emerge from a seep at the base of a limestone and dolomite formation (Palmer and Palmer, 2009). This story is a family story and never revealed in its entirety, but rather used only as another example for explaining flow and transformation.

Maunkaui: - Tornadoes

Every spring and fall humans and non-humans on the Southern Great Plains must confront a great force that comes from the chin of father sky and clouds. The enormous bellowing clouds tower to great altitudes as the earth prepares for the overwhelming winds. Great clouds pull moisture from the ground and ingest it into their enormous rounded bodies, into their souls. A great creature roams within the backside of the massive cloud formations. The Kiowas speak of Maunkaui: the wind spirit or tornado. The spirit of Maunkaui is sometimes there in the dark storm clouds of spring. The wind is relatively unpredictable. No one, including the Kiowas, knows exactly when he will appear from the clouds and trample the land. Since the Kiowas created Maunkaui:, the wind spirit can understand the Kiowa language. Even today, elders will speak to an approaching storm asking it to pass over. Such action could be interpreted as a means of controlling the environmental conditions (Palmer and Palmer, 2009).

Maunkaui: is a useful story when trying to explain the multiple vortices associated with tornadoes. We used the example of multiple horses running in a circle to interpret the complex nature of tornadoes. Large multiple vortex tornadoes can also be discussed using the story. Because Maunkaui: hides in the clouds the image is a good metaphor for explaining the complex nature of a tornadic storm's rear flanking downdraft (RFD).

Undergraduate Teachers: Models, metaphors, and stories

As a final project, we required the undergraduate students to create, develop, and presented earth and sky models using everyday materials to a local fifth grade elementary school class (6/17 or 35% of the students were of known Native American descent). Cultivating a geoscience community between professors, teachers, undergraduate students, and elementary/middle school students is an important part of 'pipeline' construction. Building a geoscience pipeline requires mentors at all levels. The undergraduate students formed small groups and chose a geoscience topic that interested them. The students had to focus on one major geosciences concept and had to use metaphors (earth and sky models) to deliver the information to the elementary students. However, we did not require the students to use Native American stories or metaphors but let them use everyday materials, including the use of pop culture elements. Indigenous communities around the world have learned to adapt to foreign materials and technologies by appropriating them as their own. Maps, geographic information systems, and visual media are often used by Native Americans to 'counter' and contest non-native representations of native people and their land resources. Countering repositions native people back onto the map and back into the broader discourse on American culture (Palmer, 2009). We asked our undergraduate students to do the same, perpetuating a living indigenous philosophy of acquiring and adopting new materials into cultures.

The undergraduate students prepared eight centers for the fifth grade students. The first goal of the centers was to get the fifth graders actively engaged in conversations and hands-on experiences with the undergraduate students and visa versa. Getting the undergraduate students to construct simple representations of complex earth systems processes was the second goal. And the third goal was to raise the understanding of earth systems and cyclical processes for both the 5th grade students and the undergraduates. The significance of this experience for the undergraduates was that they had to truly understand the geosciences concepts that they were trying to communicate. They also had to teach the fifth graders using techniques that echoed traditional Native American ways of teaching children about earth processes, while at the same time using their own popular culture to connect with these children and explain complex earth cycles. The assignment became an inquiry-based learning experience that took into consideration the age level of the students and created models that would 'hook' the kids and grab their attention.

Examples of presentations included cakes which were used to explain earth structure and plate tectonics (e.g., Wagner, 1987), a 'hydrological cycle' board game, an adaptation of an existing game, Twister, to teach elements of the rock cycle, and the use of common kitchen items to illustrate condensation. By using everyday materials and experiences, science was made accessible to the undergraduate and elementary students, just as indigenous teachings are made accessible to Navajo or Apache students using landforms encountered on a daily basis. The process of storytelling and engagement is important.

PRELIMINARY ASSESSMENT

The evaluation of the course includes both formative and summative evaluations (e.g., Bloom et al., 1971) although the focus has been on formative evaluations because the course is still evolving. The course is attracting Native American students. Seven out of thirty students (23%) claimed Native American ancestry.

TABLE 1. A SUMMARY OF STUDENT RESPONSES TO A SUMMATIVE COURSE EVALUATION

Questions	Mean[1]; SD[2] (n=27)
Geosciences are interesting	4.22, 0.58
Geosciences are very important	4.52, 0.58
Geosciences and Indigenous knowledge systems can inform one another	4.33, 0.55
Native American Art is a good medium for study some aspects of geoscience	4.30, 0.54
Storytelling and sense of place contribute to the understanding of geosciences processes	4.33, 0.55
I enjoyed interpreting images on the examinations	4.30, 0.72
I'd enjoy a career in geosciences	3.44, 0.80
I am considering majoring in geosciences	2.93, 0.55
I know what courses you have to take to become a geoscientist	3.04, 0.81
I think I could handle the coursework required to become a geoscientist	3.11, 1.25
Overall mean	3.85, 0.69

Notes:
[1]1 represents strong disagreement and 5 strong agreement;
[2]standard deviation.

We conducted a post-course five-point Likert-scale evaluation of our student's general views of geosciences, views regarding the integration of indigenous knowledge and the geosciences, and the student's anticipated future engagement with the geosciences curriculum and careers. We administered and collected N = 27 completed student surveys. The questions and results are provided in Table 1. We calculated means and standard deviations (SD) for each response ranging from strongly agree (5), agree (4), disagree (3), strongly disagree (2), and don't know (1). We did not test for statistical significance because we initially collected less than 30 evaluations. The overall rating for our course was 3.85 $\pm$ 0.69. Table 1 reveals that students responded favorably to the course content including interests in geosciences topics and considered geosciences as important areas of inquiry. Most importantly, the students ranked the integration of indigenous knowledge, art, stories, and image interpretations as being beneficial to the understanding of geosciences concepts and processes. The students were less confident regarding geosciences as a career choice or about converting to one of the geosciences majors. Based on these results, in the future more emphasis will be placed on informing future students about geosciences curriculum.

Qualitative data collected from university administered student evaluations at the end of the semester provided additional feedback. The most common constructive criticism was that more Indigenous knowledge and philosophies should be integrated the next time the course is taught. We plan to address this point the next time the course is taught.

CONCLUSION

Very few Native American students in the United States select geoscience majors. However, the University of Oklahoma is attempting to address this by creating and maintaining a geoscience 'pipeline' for Native American students. One part of this pipeline, an undergraduate course called Earth Systems of the Southern Plains, is yielding promising results. Integrating indigenous knowledge into the course by using Native American stories, metaphors, art, and images in class is having a positive influence on undergraduate students. Many of the students are fitting science into their everyday thinking. As a result, geoscience becomes less mysterious and more accessible.

Acknowledgements

The pipeline project at OU is supported by NSF grant GEO-0503604. Thanks to Dr. Joe Hobbs, Dr. Steve Semken, and Dr. Dexter Perkins for reviewing this article.

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