Sense of Place and Place-Based Introductory Geoscience Teaching for American Indian and Alaska Native Undergraduates

Steven Semken

Department of Geological Sciences and Center for Research on Education in Science, Mathematics, Engineering, and Technology, Arizona State University, Tempe, Arizona 85287-1404, semken@asu.edu

ABSTRACT

Places are localities given meaning by human experiences in them. Sense of place refers to a set of meanings of and attachments to places that are held by individuals or by groups. The cultures and educational philosophies of American Indian and Alaska Native peoples reflect rich senses of the places that make up their traditional homelands. However, sense of place does not manifest itself in proportionate enrollments in undergraduate geoscience by American Indians and Alaska Natives. This is because mainstream geoscience teaching emphasizes global syntheses over exploration and in-depth understanding of places that have prior meaning for Indigenous students, and may even depict such places in culturally-inappropriate ways. Many teachers and researchers with experience in Native educational systems recommend a greater emphasis on the study of local places, synthesis of local cultural knowledge, and community-directed activities in science education. Such a "place-based" approach is used by a small number of school systems, nearly all outside of Native communities. Place-based geoscience teaching could potentially enhance science literacy among American Indian, Alaska Native, and other underrepresented minority students, and bring more of them into the geoscience profession. However, this hypothesis has not yet been rigorously tested. Empirical and descriptive studies of place attachment and meaning among different student populations, and clearer definition of place-based teaching, are prerequisite to more authentic place-based geoscience courses and programs. Five characteristics of place-based geoscience teaching are identified here and illustrated with suggestions for implementation in diverse educational settings.

SENSE OF PLACE

Places, which are spatial localities given meaning by human experiences in them, are integral to the knowledge systems and cultural identities of traditional American Indian and Alaska Native (AI/AN) peoples (Cajete, 1994, 2000; Kelley and Francis, 1994; Basso, 1996; Kawagley and Barnhardt, 1999; Deloria and Wildcat, 2001). Traditional indigenous ways of knowing and teaching imbue youth with a rich sense of place, a concept expressed in diverse and often amorphous ways (Shamai, 1991; Brandenburg and Carroll, 1995; Hass and Nachtigal, 1998; Williams and Stewart, 1998; Kruger and Jakes, 2003; Stedman, 2003). In this paper, sense of place will denote the *meanings of* and the *attachments to* a place held by a person or a group.

Place is distinguished from space by being socially constructed and local, rather than quantitatively described and universal (Tuan, 1977). In other words, people make places out of space (Brandenburg and Carroll, 1995), and a given locality or landscape can hold widely divergent meanings for different individuals or cultures (Gruenewald, 2003). The physical environment appears to play a major role in creating and shaping sense of place (Ryden, 1993; Stedman, 2003), and in some cases a physiographic province or ecosystem may coincide with a place (Williams and Patterson, 1996). If sense of place influences the ways that people observe and interpret natural phenomena, it must influence geoscience learning, and it merits study by geoscience educators.

Social scientists and humanists have long been interested in the diverse ways that people understand and form bonds to places. Geographers consider place to be a fundamental theme of their discipline (Tuan, 1977). Anthropologists and ethnographers investigate how places are embedded in cultures (Lamb, 1993; Feld and Basso, 1996; Lippard, 1997); architects and urban planners are concerned with constructed and inhabited places (Lyndon, 2001); environmental psychologists are interested in attachment to places as an aspect of human behavior (Altman and Low, 1992; Hay, 1998); and historians have shown how places have influenced human events (Schama, 1995) and knowledge, including the evolution and spread of scientific inquiry (Livingstone, 2003).

Land managers and planners have recently been encouraged to factor sense of place into their decision-making processes, adopting a more ecologically holistic, rather than economically-driven, approach to resource use and environmental-impact assessment (Kaltenborn, 1998; Williams and Stewart, 1998; Kruger and Jakes, 2003; Williams and Vaske, 2003). Such an approach requires a clear definition or even a quantification of sense of place, and this has led to the development of psychometric models and methods (Shamai, 1991; Kaltenborn, 1998; Williams and Vaske, 2003) that will be discussed in more detail below.

Field geoscientists develop rich senses of the places where they do their research; Rossbacher (2002) evocatively described this phenomenon as a definitive and appealing attribute of a geological career. Other geoscientists have argued that the intimate, intuitive, or spiritual knowledge of places acknowledged by many in the profession appeals to a fundamental human need for direct contact with the Earth, and should be brought to bear on current problems of scientific illiteracy and anthropogenic environmental degradation (Leveson, 1971; Savoy; 1992; Moores, 1997). Wherever else this need or desire to acknowledge "kinship with the Earth" exists outside of the geosciences or other field-based natural sciences, it remains strong in AI/AN cultures.

INDIGENOUS EXPRESSIONS OF SENSE OF PLACE

The science educator Gregory Cajete (Tewa) has written that Native people traditionally perceive themselves as embedded in a web of dynamic and mutually-respectful relationships among all of the natural features and phenomena of their homelands (Cajete, 2000, p. 178-180).

Hence geologic, physiographic, hydrologic, and climatic attributes of the places American Indians and Alaska Natives inhabit become inseparable components of their culture, regularly met in daily life (Rock Point Community School, 1982; Kawagley, 1995), and invoked in stories (Zolbrod, 1984; Morton and Gawboy, 2000), arts (Harjo and Strom, 1989; Ortiz, 1992; Willink and Zolbrod, 1996), and philosophy of nature (Aronilth, 1994; Semken and Morgan, 1997).

Cajete (1994, p. 47) describes the understanding of one's physical surroundings as the first developmental step of Indigenous knowledge. AI/AN children seem to have such awareness early. Monhardt (2003) investigated how Diné children perceive science by asking a group of Diné students at an elementary school in southern Utah to draw pictures of scientists at work. Mainstream children who are given the same task overwhelmingly hew to the stereotype of the scientist in a white coat working in a laboratory (Barman, 1999). However, a majority of the Diné students depicted scientists as working outdoors, and in many cases, among landforms characteristic of their Colorado Plateau homeland. Monhardt (2003) interpreted this as indicative of a strong attachment to place.

It could be concluded that sense of place would lead many AI/AN students to pursue studies and careers in the Earth and environmental sciences, but this has not been the case. Monhardt (2003) noted that whereas the young Diné students in her study strongly associated science with local geological landscapes, they did not see themselves as potential scientists working in these environments. Indigenous undergraduate and graduate enrollments in the geosciences and other natural sciences have been miniscule, even when compared to the small percentage of American Indians and Alaska Natives in the overall population of the United States (Geisler et al., 2000; Riggs and Semken, 2001; Ogunwole, 2003). This trend continues even as other underrepresented minorities have begun to earn advanced degrees in science in increasing numbers (Mervis, 2003). Hence AI/AN geoscience professionals remain scarce, while a host of environmental and resource-management issues calling for geoscientific input persist in their communities (Riggs and Semken, 2001). At the same time, the geosciences are undoubtedly poorer for the lack of intellectual contributions from the people who have been observing the natural phenomena of the Americas the longest (Suzuki and Knudtson, 1992; Semken, 1997; Deloria and Wildcat, 2001).

CULTURAL DISCONTINUITY WITH GEOSCIENCE

It is likely that many diverse factors limit the participation of American Indians and Alaska Natives in the geoscience community, including a lack of role models and mentors (American Indian Science and Engineering Society, 1995; Zappo, 1998; Mullens, 2001) and the absence of Earth science classes beyond the middle-school level, which is a problem common to schools throughout the United States (Barstow et al., 2002). However, the educators and researchers most directly engaged with the difficulties AI/AN students have in learning science nearly always cite some form of cultural discontinuity as a root cause. This theory holds that the practices and practitioners of mainstream or "Western" scientific research and education constitute an identifiable culture that is foreign to, and typically incompatible with, traditional indigenous norms and ways of knowing (Rhodes, 1994; Aikenhead, 1996; Nelson-Barber and Estrin, 1995; Kawagley et al., 1998; Deloria and Wildcat, 2001; Mullens, 2001). When Western scientific explanations and teaching methods are brought to bear on subjects that AI/AN students already understand from a traditional frame of reference (subjects that may include the physiography and natural history of their homelands), cognitive and even moral conflicts may limit or preclude any effective engagement with Western science. Aikenhead (1996, 1997) and Aikenhead and Jegede (1999) describe this phenomenon as a "cultural border" between lifeways and the science classroom that few Indigenous students negotiate successfully.

In the case of the natural sciences, differing values and meaning attached to places contribute to cultural discontinuity. Indigenous educators have cited as examples the Western scientific ideal of analytical detachment from the objects of study and the perception of scientists as conquerors and despoilers of nature (Kawagley, 1995; Kawagley and Barnhardt, 1999; Murray, 1997; Riggs, 1998). In some Native nations, geoscience may be associated with tragic historical experiences, such as military and Federal surveys into lands supposedly inviolable by treaty, often as a prelude to seizure and relocation (Brown, 1970; Savoy, 1992; Semken et al., 1996). It may also be linked in many minds to episodes of resource exploration, mining, and waste disposal in Indian country that occurred without concern for the spiritual value of places (Kelley and Francis, 1994, p. 149-152), and which left behind environmental and public-health degradation that outlasted any economic benefits (Churchill and LaDuke, 1992; Eichstaedt, 1994; LaDuke, 1999).

Other points of cultural discontinuity relating to places are symbolic. Geoscience textbooks and other mainstream teaching materials frequently invoke mechanical metaphors to describe Earth systems and processes (e.g., the internal and external "heat engines"; Keller, 1962; Press et al., 2004), whereas traditional indigenous knowledge describes geological processes as manifestations of living systems (Aikenhead, 1997; Haskell Indian Nations University, 2000; Morton and Gawboy, 2000) more akin to the Gaia model of Lovelock (1979). When places that hold prior meaning for AI/AN students are featured as "textbook examples," they are typically shown in column-sized images or sidebars, described only in terse captions, and identified by non-Native place names. These places may be depicted in unfamiliar, or even culturally-offensive, contexts involving mining, waste disposal, or public recreation.

However, the most significant cultural discontinuity between Western geoscience education and traditional AI/AN teaching may be the difference in their philosophies. The desired outcome of a typical introductory physical or historical geoscience course is for students to understand the general principles and laws that globally govern the origin and evolution of Earth materials, structure, processes, and history. Commercial textbooks and related media reinforce this approach by presenting geoscience concepts in expository fashion and illustrating them by means of the most current, dynamic, or photogenic phenomena culled from around the Earth and other planets. The subject matter in mainstream physical geology is typically organized by materials and processes, often beginning with some of the most abstract or advanced scientific ideas (e.g., crystal structure or solar nebula theory), and historical-geology content is organized hierarchically by time. In contrast, AI/AN teaching emphasizes locally relevant knowledge (Kawagley, 1995; Deloria and Wildcat, 2001), favors insight gained from patient observation and reflection in places over that obtained by causal questioning (Beck et al., 1996; Cajete, 2000), and may organize information geospatially as well as thematically.

For example, Benally (1987) and Aronilth (1994) describe how Diné knowledge is classified into four sets, each associated with a cardinal direction and a co-located sacred mountain on the periphery of Diné bikéyah, the traditional homeland. These groupings of knowledge are properly listed or presented in a sequence corresponding to a "sunwise" cycle beginning in the East and ending in the North, representing the apparent movement of the Sun across the sky as seen from the Colorado Plateau, and symbolizing both a day and a human lifespan (Aronilth, 1994). Each class of knowledge (ethics and spirituality, vocation, social well-being, understanding of nature) is thus associated with a sacred place, and symbolically with a time of day or period in one's life when that knowledge is commonly put to use.

Western scientific and place-centered Indigenous teaching philosophies need not be mutually exclusive. Cajete (1994), American Indian Science and Engineering Society (1995), Kawagley (1995), Assembly of Alaska Native Educators (1998), Aikenhead et al. (2000), and Stephens (2000) have published models or guidelines for science curricula that integrate both worldviews. Benally (1987) mapped a list of Western disciplines, including the natural sciences, onto the Diné system as a guide to cross-cultural curriculum design. Semken and Morgan (1997) discussed similarities between Diné ethnogeology (indigenous geological knowledge based on empirical observation) and Earth systems science.

PLACE-BASED TEACHING

Place-based (also called place-centered or place-conscious) teaching, in which the physical attributes and the cultural, historic, and socioeconomic meanings of places (i.e., sense of place) define and infuse content and pedagogy, and in which students regularly work in the local outdoor environment or in the community, has been practiced at the elementary and secondary school levels for many years and in diverse regions of the United States (Lieberman and Hoody, 1998; Woodhouse and Knapp, 2000; Sobel, 2004). The approach has been increasingly championed as an alternative to current educational practices that emphasize global standardization, incessant testing, and a focus on competitiveness and career training (Haas and Nachtigal, 1998; Knapp, 1999; Gibbs and Howley, 2000; Woodhouse and Knapp, 2000; Gruenewald, 2003; Sobel, 2004). Place-based education is intended to promote sustainable lifestyles and economies suited to the ecological and cultural attributes of places and regions. Although this objective is in keeping with AI/AN philosophies, most place-based programs have thus far been implemented in regions with few or no Native inhabitants, probably because these communities lack the financial and human resources needed to reconfigure their school systems. Two place-based educational programs now actively serving a number of AI/AN schools were both initiated with federal grant funding: one in Alaska (Barnhardt and Kawagley, 2004) and one on the Colorado Plateau (Orris, 2004; Sobel, 2004, p. 88-90).

In introductory undergraduate geoscience, courses and texts in the geology or natural history of National Parks (e.g., Harris et al., 2003), states (e.g., Nations and Stump, 1996), or local areas (e.g., Butler et al., 2000) are familiar uses of place as the context or theme for content and pedagogy. A noteworthy innovation is a field course in the National Parks and Monuments of eastern Utah that also integrates authentic research methods and problem-solving (Huntoon et al., 2001). These courses are often intended to enhance the science literacy of pre-service teachers. However, they are generally not offered for core credit toward a degree in geoscience, which limits their use for recruitment. An exemplar that is strongly place-based and designed to recruit minority students into geoscience majors is a course in the geology and development of modern Africa by Tewksbury (1995). But courses such as this have yet to be offered at most undergraduate institutions serving large numbers of AI/AN students (Riggs and Semken, 2001).

PLACE-BASED TEACHING AND LEARNING ARE SITUATED

Situated learning theory (Lave, 1988; Brown et al., 1989; Lave and Wenger, 1991) holds that all learning is a function of the sociocultural or environmental context in which it occurs, and thus knowledge and skills are most effectively taught in settings and through activities that authentically involve or engage such knowledge and skills. Place-based teaching is an example of a situated teaching method; others include case-based and problem-based teaching (see Lang, 1998, and Smith et al., 1995, for examples of these methods applied in geology). It is important to note that place-based and other situated teaching methods differ from other approaches in context, not in cognitive level. There is no reason why the knowledge and skills learning objectives for a place-based introductory course should be of lower order than those for a more catholic introductory course.

HOW EFFECTIVE IS PLACE-BASED TEACHING?

Advocates of place-based teaching for AI/AN students generally speak from deep knowledge of Indigenous cultures, experience in teaching Native students, and expressed intentions to help AI/AN people gain access to the community and benefits of Western science. Existing curricula and programs offer models for an undergraduate geoscience course in which local or regional geology determines topical content, AI/AN philosophies of education inform pedagogy, and indigenous or local place knowledge (e.g., aboriginal names, oral histories, community lifeways, local issues) adds meaning and relevance for students. Service-learning activities in support of community scientific literacy or environmental quality (Mogk and King, 1995; Liu et al., 2004, Sobel, 2004) may also be included. Sense of place, acknowledged and enriched in this manner, would provide scaffolding for construction of new geological knowledge.

This hypothesis has yet to be rigorously tested, particularly at the introductory undergraduate level, although the results of three recent studies are relevant. Lieberman and Hoody (1998) conducted a meta-analysis of the results of place-based educational programs (their label is "environment as the integrating context for learning" or EIC) at forty schools nationwide, well-distributed by grade and geography. Their study combined qualitative and quantitative methods, including surveys of school characteristics, teacher knowledge and behaviors, student learning and attitudes, and student performance on state-mandated standardized tests; as well as regular school visits and interviews. Lieberman and Hoody concluded that a place-based EIC approach enabled K-12 students to learn scientific subjects more effectively than did a traditional decontextualized program, and yielded dividends such as enhanced student enthusiasm, greater appreciation for cultural diversity, and deeper understanding of community issues.

In quantitatively assessing the effectiveness of their field- and research-based introductory geoscience course in Utah, Huntoon et al. (2001) found strongly positive effects on students' knowledge of and attitudes toward geoscience in particular and science in general. However, as Huntoon et al. themselves noted, their sample size was small (only 15 students), and additional assessments in subsequent course offerings will be necessary before these results can be interpreted with confidence.

Riggs (2004) demonstrated that the most successful and persistent of the few geoscience education programs in AI/AN and Canadian First Nations communities made regular use of Indigenous knowledge and field-based learning.

RESEARCH DIRECTIONS IN PLACE-BASED TEACHING

Further research into sense of place in diverse student populations and the effectiveness of place-based geoscience teaching on student learning is needed. Place theory studies are now well established in environmental psychology and rural sociology, offering useful models for geoscience educators. Here two research questions are posed and briefly discussed in the context of relevant published work, mostly in social sciences.

Can sense of place be characterized and measured for different communities of learners, including AI/AN students? - Practical application of place theory in environmental management, planning, design, or education calls for quantitative characterization of sense of place, and several investigators have published instruments developed for this purpose.

Shamai (1991) constructed a seven-point ordinal scale intended as a measurement of sense of place, but which effectively measures place attachment, one of the two principal components of sense of place. The Shamai scale was developed empirically from a survey of Jewish high-school students in Toronto, using Likert-like scaled questionnaires, and intended to compare their feelings toward their city, their province (Ontario), and their nation (Canada); and to measure the influence of their school on these attachments. The ordinal scale developed reflects a spectrum of place attachment from obliviousness to complete commitment (Shamai, 1991, p. 349-350): not having any sense of place (0), knowledge of being located in a place (1), belonging to a place (2), attachment to a place (3), identifying with the place goals (4), involvement in a place (5), and sacrifice for a place (6). Shamai (1991, p. 353) found that the levels of attachment of the students to city, province, and nation were all positively correlated, indicating that attachments to places "nested" at different spatial or cultural scales need not dilute, and may in fact reinforce, each other.

Kaltenborn (1998) used a modified version of the Shamai scale, accounting more explicitly for meaning of place, to develop a typology of residents of the Svalbard archipelago according to attachment to their homeland. This study provided further confirmation that at least some components of sense of place can be measured empirically and compared among different individuals or groups.

Williams and Vaske (2003) addressed the important issues of validity and generalizability in measurement of place attachment. To be considered valid, a psychometric instrument should be a specific and accurate test of theory (e.g., a measure of place attachment rather than political opinion; this is called construct validity) and should show positive correlation only among variables hypothesized as related to the theoretical concept measured (e.g., perceived spiritual or economic value of a place would be expected to correlate positively with place attachment, but age or gender would not; this is called convergent validity). A generalizable place-attachment instrument can be used reliably for places and with study groups other than those for which it was initially designed. Williams and Vaske developed a 12-item Likert-scale survey to measure two dimensions of place attachment previously identified in theoretical studies (Williams and Roggenbuck, 1989): place dependence, the capacity of a place to support a person's activities or goals; and place identity, the emotional attachment to a place.

Williams and Vaske developed surveys for seven different public-lands recreation sites and administered them to a total of 2819 university students and park visitors. They confirmed construct validity by factor analysis, convergent validity by correlating place attachment with familiarity and frequency of visitation, and generalizability by comparing place dependence and place identity data among the different localities identified in the survey. They also demonstrated that that the two dimensions of place dependence and place identity are sufficient to reliably measure place attachment, using four to six items for each dimension. The Williams and Vaske 12-item survey has now been adapted for place-attachment research among different groups of geoscience students at Arizona State University and collaborating institutions (Semken and Piburn, 2004).

Stedman (2003) notes that quantitative place-attachment studies such as these have focused on one evaluative component of sense of place but not the other, the meanings of places. A more robust and more useful theory of sense of place will require descriptive research into the specific meanings that places have for different people and groups, how these meanings are created and evolve, the relationship between sense of place and behavior, and the influence of the physical environment on sense of place (Stedman, 2003, p. 826-827).

In the case of AI/AN cultures, research into place meanings (including but not limited to ethnogeological knowledge) is likely to require not only review of published work by Indigenous scholars and artists and anthropologists, but new ethnographic and cognitive research as well. Even if only published material is used, and certainly where any research involving student surveys, focus groups, or interviews with Elders is to be conducted, investigators should be fully sensitive to specific cultural constraints on use and protection of traditional knowledge (e.g., Smith, 1999; Assembly of Alaska Native Educators, 2000). Research involving students and community members may also require prior approval by Tribal institutional review boards (Libarkin and Kurdziel, 2004).

Can the essential characteristics of place-based teaching be identified for purposes of curriculum development, implementation, and assessment? - As place-based teaching is offered as an alternative to tyrannies of mass marketing, standardization, and consequent decontextualization, it would be counter-productive to attempt to define its characteristics too globally. However, to design or assess a new place-based introductory geoscience course, or to vet existing courses for place consciousness, a common set of general attributes is useful. Toward this end, criteria identified by a number of pioneering workers (MacIvor, 1995; Lieberman and Hoody, 1998; Kawagley and Barnhardt, 1999; Cajete, 2000; Woodhouse and Knapp, 2000; Gruenewald, 2003) are distilled into five characteristics offered here as working guidelines. Although these are based mostly on work relating to AI/AN students, they suggest implementation strategies for place-based geoscience teaching in any context.

FIVE ESSENTIAL CHARACTERISTICS OF PLACE-BASED GEOSCIENCE EDUCATION

1. **Its content focuses explicitly on the geological and other natural attributes of a place** - The scope and sequence of courses emphasize understanding of local stratigraphy, structure, geomorphology, climate, geologic history, and resources. Students learn to interpret Earth systems in the context of their surroundings rather than "covering" a textbook- or tradition-driven list of topics.
2. **It integrates, or at least acknowledges, the diverse meanings that place holds for the instructor, the students, and the community** - AI/AN ethnogeologic and other place knowledge is integrated or discussed, as appropriate, and the indigenous language and local place names are used in concert with mainstream geological terminology. Representations of place in the works of Indigenous or local artists (e.g., Harjo and Strom, 1989) can be incorporated; students and community Elders are invited to contribute their own place knowledge.
3. **It teaches by authentic experiences in that place, or in an environment that strongly evokes that place** - Students work in the field and with local geological and paleontological specimens as much as possible. Regional maps, cross-sections, and images have pride of place in the laboratory or classroom; labels and legends are multilingual; design of handouts, presentation graphics and online materials is influenced by landscape patterns, colors, and Indigenous artistic styles.
4. **It promotes and supports ecologically- and culturally-sustainable living in that place** - Courses include case-based or problem-based activities relevant to local environmental or economic issues, and presenting diverse perspectives on them. Service learning supports community science literacy or environmental quality. Content and pedagogy are sensitive to the cultural mores of the community. Faculty colleagues in Indigenous studies, Elders, or other cultural experts may be asked to review curriculum materials.
5. **It enriches the sense of place of students and instructor -** Geoscience teachers seek to gain expertise in indigenous language and knowledge from their students and colleagues, and they become interested in the cultural significance of their research localities. Their teaching encourages students to share geological knowledge of local places with their family, friends, and community; and to become practiced, life-long observers of geological and other natural phenomena in their home environment.

AN EXAMPLE FROM THE NAVAJO NATION

Tsé na'alkaah (literally, "rock study" in the Diné language) or Indigenous Physical Geology, a course based on the Colorado Plateau and Navajo culture taught by the author on the Navajo Nation, incorporates each of these characteristic attributes. The semester-long course is offered in two ninety-minute interactive lecture classes and one three-hour field or laboratory class per week. The content is presented as twelve modules that address different and important aspects of Plateau geology, climate, and environmental quality. Global plate tectonics, mountain-building, and magmatism are illustrated not only by processes now occurring in the active plate boundary to the west, but by the geologic stories from the Yavapai-Mazatzal, Ancestral Rockies, and Laramide orogenies and post-Laramide volcanism that built and shaped the Plateau. In the lab and in the field, students explore Paleozoic to Tertiary paleoenvironments and their regional legacy, such as redrock landscapes, fossils and fossil fuels, and groundwater basins. Sedimentary systems, dryland geomorphic processes, and the Colorado River drainage are prominent in the curriculum, just as they are on the Plateau.

In accordance with the fundamental Diné ethnogeological principle of duality in nature (Semken and Morgan, 1997), which describes natural processes of change as interactions between a dynamic Earth (Nohosdzáán) and Sky (Yádilhil), the module sequence is represented as a cyclical intellectual path from the surface through the solid Earth, to Earth-Sky interactions, and finally to fluid-Earth and extraterrestrial processes. Figure 1 is a simplified graphic syllabus for the course illustrating its emphasis on the Colorado Plateau, the spatial and structural relationships among the twelve topical modules, and the cyclical representation of the course schedule.

To facilitate the use of Diné ethnogeologic terminology and place names, students and faculty collaborated to compile and publish a bilingual geological thesaurus (Blackhorse et al., 2003). The reader is referred to this paper (downloadable at http://semken.asu.edu) for translations of the Diné terms in Figure 1.

In lieu of exercises in a standard laboratory manual, Tsé na'alkaah students learn rock, fossil, and soil interpretation using specimens collected from the Plateau and Southern Rockies. A new website with place-based textual and graphic course materials is under development at Arizona State University; in the meantime students still use a textbook for background reading. However, they also purchase and regularly work with two inexpensive local maps: a U.S. Geological Survey 1:100,000 topographic quadrangle, and the American Association of Petroleum Geologists Southern Rockies highway geologic map.

Tsé na'alkaah students have addressed issues of environmental and cultural sustainability by researching and giving local presentations on groundwater contamination from Cold War-era uranium mining and

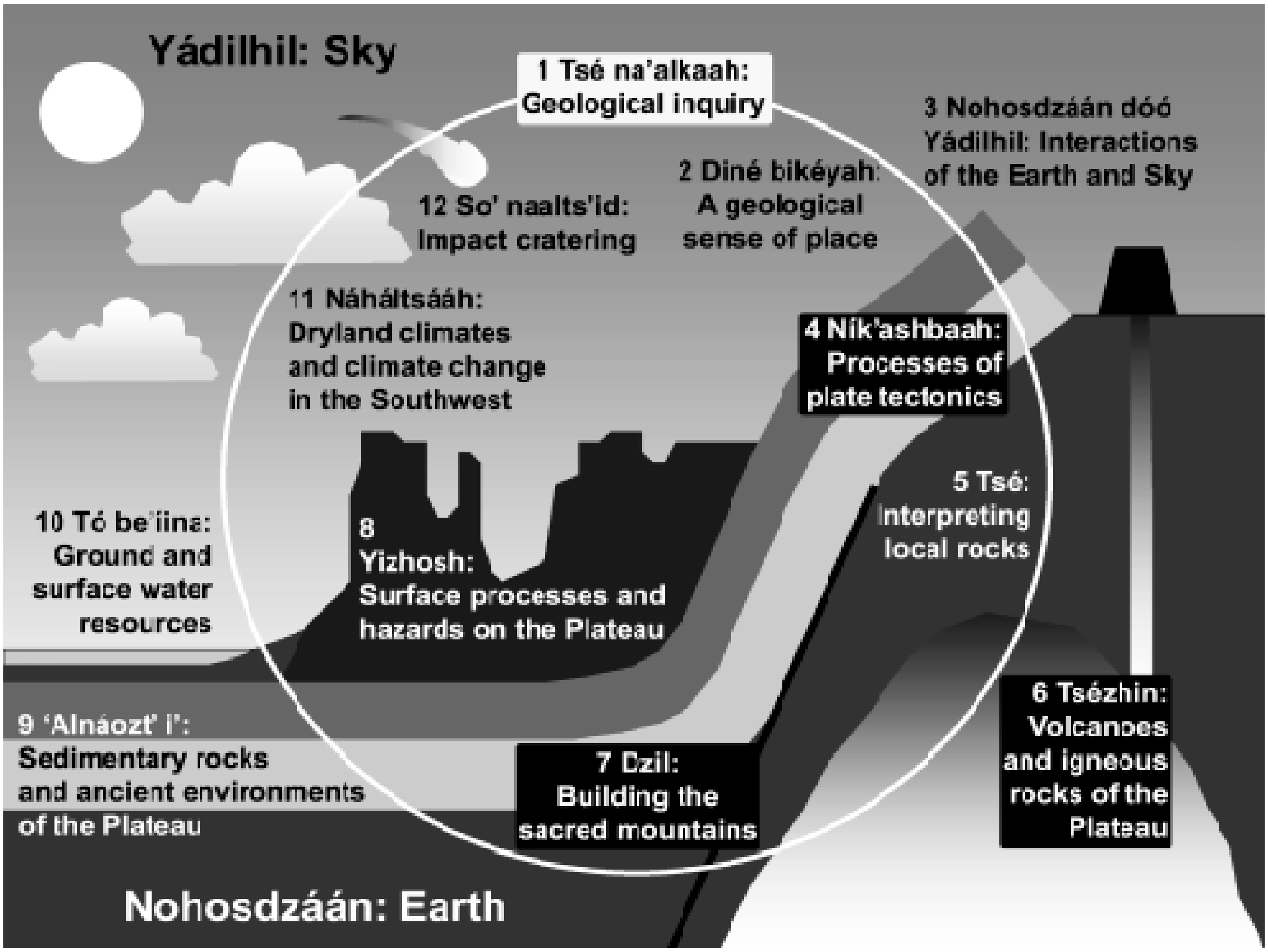


Figure 1. Graphic syllabus of Tsé na'alkaah, an Indigenous Physical Geology course based on the Colorado Plateau and Diné cultural knowledge.

milling on the Plateau, flyash disposal at nearby coal-fired power plants, and soil erosion and dune reactivation exacerbated by the ongoing multi-year regional drought.

PLACE-BASED GEOSCIENCE TEACHING IN CULTURALLY DIVERSE EDUCATIONAL SETTINGS

Implementation of a place-based geoscience course may be relatively easy in places where students share a common cultural heritage and attachments to the land, such as Tribal colleges located on Native homelands. However, increasing numbers of AI/AN undergraduates are pursuing degrees at larger regional universities (Riggs and Semken, 2001; Auffret, 2003), many of which have improved their efforts at recruiting and retaining minority students. In these academic environments, a handful of Indigenous students in a lecture-format introductory-geology course may be sprinkled among heterogeneous ranks of students, many of whom may come from other places far away.

Can teaching based on sense of place suit natives and newcomers equally well? It is known that tourists and other visitors can develop strong attachments to places far from their homes. Williams and Stewart (1998) remarked that "it is not the possessors of meanings that are local, but the meanings themselves (p. 19)." Teaching that deliberately enriches a local sense of place can potentially stimulate the interest of all students in the physical attributes of those places, and in geoscientific ways of interpreting them. Where the physiography or cultural geography the aboriginal inhabitants knew has been obliterated by urbanization or other changes, geoarchaeology combined with mapping and visualization technologies can be used to recreate them (e.g., Lubick, 2004). EarthScope, a comprehensive geophysical and geological study of North America, promises a wealth of new subsurface structural detail and clues to the assembly of the continent as it progresses from west to east in the "lower forty-eight" and thence to Alaska (EarthScope Education and Outreach Committee, 2003). These data can potentially enrich place-based curricula anywhere in the United States. Where a diversity of cultures now resides, such as the urban areas along both coasts and the Great Lakes, or in the Southwest, place-based teaching can integrate the local knowledge garnered by successive immigrant groups as they became established (Riggs, 2003).

Students, having obtained geological knowledge and skills through study of local places, can also be challenged to research the geology of their own hometowns, or of other places important to them (Pestrong, 2000). This is a capstone activity in the large-enrollment, Arizona-based physical-geology laboratory course at Arizona State University (Reynolds et al., 2003). Geoscience teachers are encouraged to use sense of place no matter where or whom they teach.

GEOLOGICAL MEANING SITS IN PLACES

As described in a celebrated study by Basso (1996), the Ndee (Western Apache) people of the mountainous semi-arid Transition Zone of west-central Arizona link important allegorical stories to the places where they are said to have occurred, and regularly recount these stories for teaching and counseling. Descriptive place names (e.g., Coarse-Textured Rocks Lie Above in a Compact Cluster, Line of White Rocks Extends Up and Out) have long since become shorthand for the lessons they exemplify, and are central to Ndee cultural literacy. As explained by the late Dudley Patterson, an Ndee Elder, "Wisdom sits in places. It's like water that never dries up. You need to drink water to stay alive, don't you? Well, you also need to drink from places. You must remember everything about them. You must remember what happened at them long ago. You must think about it and keep thinking about it" (Basso, 1996, p. 127).

Geological meaning also sits in places. Geoscience teachers are challenged to investigate, implement, and assess place-based teaching as a means to enhance the scientific literacy of all students and the diversity of the geoscience community.

ACKNOWLEDGMENTS

The author wishes to express his appreciation for years of generous and patient instruction from a host of Diné colleagues, students, family, and neighbors. He also thanks Dexter Perkins, Greg Gagnon, and an anonymous reviewer for highly constructive reviews. Development and implementation of place-based teaching at Diné College were supported by National Science Foundation grants DUE-9653973 and ESR-9813616, and by WERC, a consortium for environmental education and technology development. All opinions, findings, conclusions, and recommendations presented in this publication are those of the author and do not necessarily reflect the views of the National Science Foundation or WERC.

REFERENCES

Aikenhead, G.S., 1996, Science education: border crossing into the subculture of science, Studies in Science Education, v. 27, p. 1-52.

Aikenhead, G.S., 1997, Toward a First Nations cross-cultural science and technology curriculum, Science Education, v. 81, p. 217-238.

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

Aikenhead, G., Belcourt, G., Brizinski, M., Gold, D., Lemaigre, K., Nagy, S., Stobbe, E., Sanderson, H., Lafleur, A., and Campbell, A., 2000, Rekindling traditions: Cross-Cultural Science and Technology Units Project, http://capes.usask.ca/ccstu/ (June, 2004).

Altman, I., and Low, S.M., eds., 1992, Place Attachment, New York, Plenum Press, 314 p.

American Indian Science and Engineering Society, 1995, Educating American Indian/Alaska Native Elementary and Secondary Students: Guidelines for Mathematics, Science, and Technology Programs, Boulder, Colorado, American Indian Science and Engineering Society, 38 p.

Aronilth, W., Jr., 1994, Diné bi bee Óhoo'aah bá Silá: An Introduction to Navajo Philosophy, Tsaile, Arizona, Center for Diné Studies, Diné College, 130 p.

Assembly of Alaska Native Educators, 1998, Alaska Standards for Culturally-Responsive Schools, Fairbanks, Alaska, Alaska Native Knowledge Network, 24 p.

Assembly of Alaska Native Educators, 2000, Guidelines for Respecting Cultural Knowledge, Fairbanks, Alaska, Alaska Native Knowledge Network, 31 p.

Auffret, S., 2002, ASU shows large minority student increase over ten years, Arizona State University Insight, v. 23, no. 19 (13 December), p. 2.

Barman, C.R., 1999, Students' views about scientists and school science: engaging K-8 teachers in a national study, Journal of Science Teacher Education, v. 10, p. 43-54.

Barnhardt, R., and Kawagley, A.O., 2004, Culture, chaos, and complexity: catalysts for change in Indigenous education, Cultural Survival Quarterly, v. 27, p. 59-64.

Barstow, D., Geary, E., Yazijian, H., and Schafer, S., eds., 2002, Blueprint for change: report from the National Conference on the Revolution in Earth and Space Science Education, Cambridge, Massachusetts, TERC Center for Earth and Space Science Education, 100 p.

Basso, K.H., 1996, Wisdom Sits in Places, Albuquerque, University of New Mexico Press, 171 p.

Beck, P.V., Walters, A.L., and Francisco, N., 1996, The Sacred: Ways of Knowledge, Sources of Life, Tsaile, Navajo Nation, Arizona, Navajo Community College Press, 368 p.

Benally, H.J., 1987, Diné bo'óhoo'aah bindii'a': Navajo philosophy of learning, Diné be'iina': a journal of Navajo life, v. 1, p. 133-148.

Blackhorse, A., Semken, S., and Charley, P., 2003, A Navajo-English thesaurus of geological terms, in: Lucas, S.G., Semken, S.C., Berglof, W.R., and Ulmer-Scholle, D.S., editors, Geology of the Zuni Plateau, New Mexico Geological Society Guidebook 54, p. 103-108.

Brandenburg, A.M., and Carroll, M.S., 1995, Your place or mine?: the effect of place creation on environmental values and landscape meanings, Society and Natural Resources, v. 8, p. 381-398.

Brown, D., 1970, Bury My Heart at Wounded Knee: an Indian History of the American West, New York, Holt, Rinehart, and Winston, 487 p.

Brown, J.S., Collins, A., and Duguid, P., 1989, Situated cognition and the culture of learning, Educational Researcher, v. 18, p. 32-42.

Butler, R.F., Hall-Wallace, M., and Burgess, T., 2000, A sense of place: at home with local natural history, Journal of College Science Teaching, v. 30, p. 252-255.

Cajete, G., 1994, Look to the Mountain: an Ecology of Indigenous Education, Skyland, North Carolina, Kivakí Press, 243 p.

Cajete, G., 2000, Native Science: Natural Laws of Interdependence, Santa Fé, New Mexico, Clear Light Publishers, 315 p.

Churchill, W., and LaDuke, W., 1992, Native North America: the political economy of radioactive colonialism, in: Jaimes, M.A., editor, The State of Native America, Genocide, Colonization, and Resistance, Boston, South End Press, p. 241-266.

Deloria, V., Jr., and Wildcat, D., 2001, Power and Place: Indian Education in America, Golden, Colorado, Fulcrum Resources, 168 p.

EarthScope Education and Outreach Committee, 2003, EarthScope: an unprecedented opportunity for education and outreach in the Earth sciences, Education and Outreach Program Plan, 52 p.
Eichstaedt, P.H., 1994, If You Poison Us: Uranium and Native Americans, Santa Fé, New Mexico, Red Crane Books, 263 p.
Feld, S., and Basso, K.H., editors., 1996, Senses of Place, Santa Fé, New Mexico, School of American Research Press, 293 p.
Geisler, J., Czujko, R., and Henly, M., 2000, Earth and space science PhDs, class of 1999: American Geophysical Union and American Geological Institute Report, www.agu.org/sci_soc/cpst/employment_survey.html (June, 2004).
Gibbs, T.J., and Howley, A., 2000, "World-class standards" and local pedagogies: can we do both?, Digest EDO-RC-00-8, Charleston, West Virginia, ERIC Clearinghouse on Rural Education and Small Schools, Appalachia Educational Laboratory, 2 p.
Gruenewald, D.A., 2003, Foundations of place: a multidisciplinary framework for place-conscious education, American Educational Research Journal, v. 40, p. 619-654.
Haas, T., and Nachtigal, P., 1998, Place Value: an Educator's Guide to Good Literature on Rural Lifeways, Environments, and Purposes of Education, Charleston, West Virginia, ERIC Clearinghouse on Rural Education and Small Schools, Appalachia Educational Laboratory, 72 p.
Harjo, J., and Strom, S., 1989, Secrets From the Center of the World, Tucson, University of Arizona Press, 67 p.
Harris, A.G., Tuttle, E., and Tuttle, S.D., 2003, Geology of National Parks (6th edition), Dubuque, Iowa, Kendall-Hunt, 850 p.
Haskell Indian Nations University, 2000, Mother Earth's stories: an introduction to geological processes, Reston, Virginia, U.S. Geological Survey, 30-minute video.
Hay, R., 1998, Sense of place in developmental context, Journal of Environmental Psychology, v. 18, p. 5-29.
Huntoon, J.E., Bluth, G.J.S., and Kennedy, W.A., 2001, Measuring the effects of a research-based field experience on undergraduates and K-12 teachers, Journal of Geoscience Education, v. 49, p. 235-248.
Kaltenborn, B.P., 1998, Effects of sense of place on responses to environmental impacts: a study among residents in Svalbard in the Norwegian high Arctic, Applied Geography, v. 18, p. 169-189.
Kawagley, A.O., 1995, A Yupiaq Worldview: a Pathway to Ecology and Spirit, Prospect Heights, Illinois, Waveland Press, 166 p.
Kawagley, A.O., and Barnhardt, R., 1999, Education indigenous to place: Western science meets Native reality, in: Smith, G.A., and Williams, D.R., editors., Ecological Education in Action: on Weaving Education, Culture, and the Environment, Albany, State University of New York Press, p. 117-140.
Kawagley, A.O., Norris-Tull, D., and Norris-Tull, R.A., 1998, The Indigenous worldview of Yupiaq culture: its scientific nature and relevance to the practice and teaching of science, Journal of Research in Science Teaching, v. 35, p. 133-144.
Keller, W.D., 1962, The Earth a slave to energy, Journal of Geological Education, v. 10, p. 1-8.
Kelley, K.B., and Francis, H., 1994, Navajo Sacred Places, Bloomington, Indiana University Press, 260 p.
Knapp, C.E., 1999, In Accord With Nature: Helping Students Form an Environmental Ethic Using Outdoor Experience and Reflection, Charleston, West Virginia, ERIC Clearinghouse on Rural Education and Small Schools, Appalachia Educational Laboratory, 166 p.
Kruger, L.E., and Jakes, P.J., 2003, The importance of place: advances in science and application, Forest Science, v. 49, p. 819-821.
LaDuke, W., 1999, All Our Relations: Native Struggles for Land and Life, Cambridge, Massachusetts, South End Press, 242 p.
Lamb, D., 1993, The Sense of Place: Listening to Americans, New York, Times Books, 290 p.
Lang, H.M., 1998, A case study approach to teaching environmental mineralogy, Journal of Geoscience Education, v. 46, p. 354-362.
Lave, J., 1988, Cognition in Practice: Mind, Mathematics, and Culture in Everyday Life, New York, Cambridge University Press, 214 p.
Lave, J., and Wenger, E., 1991, Situated Learning: Legitimate Peripheral Participation, New York, Cambridge University Press, 138 p.
Leveson, D., 1971, A Sense of the Earth, New York, Anchor Natural History Books, 176 p.
Libarkin, J.C., and Kurdziel, J.P., 2004, Research methodologies in science education: human subjects and education research, Journal of Geoscience Education, v. 52, p. 199-203.
Lieberman, G.A., and Hoody, L.L., 1998, Closing the Achievement Gap: Using the Environment as an Integrating Context for Learning, San Diego, California, State Education and Environment Roundtable, 106 p.
Lippard, L.R., 1997, The Lure of the Local: Senses of Place in a Multicentered Society, New York, New Press, 325 p.
Liu, L., Philpotts, A.R., and Gray, N.H., 2004, Service-learning practice in upper division geoscience courses: bridging undergraduate learning, teaching, and research, Journal of Geoscience Education, v. 52, p. 172-177.
Livingstone, D.N., 2003, Putting Science in its Place: Geographies of Scientific Knowledge, Chicago, The University of Chicago Press, 234 p.
Lovelock, J.E., 1979, Gaia, a New Look at Life on Earth, New York, Oxford University Press, 157 p.
Lubick, N., 2004, Digging below Manhattan, Geotimes, v. 49, p. 26-27.
Lyndon, D., 2001, Caring about places, Places, v. 14, p. 2-3.
MacIvor, M., 1995, Redefining science education for Aboriginal students, in: Battiste, M.A., and Barman, J., editors., First Nations Education in Canada: The Circle Unfolds, Vancouver, University of British Columbia Press, p. 73-98.
Mervis, J., 2003, Down for the count?, Science, v. 300, p. 1070-1074.
Mogk, D.W., and King, J.L., 1995, Service learning in geology classes, Journal of Geological Education, v. 43, p. 461-465.
Monhardt, R.M., 2003, The image of the scientist through the eyes of Navajo children, Journal of American Indian Education, v. 42, p. 25-39.
Moores, E.M., 1997, Geology and culture: a call for action, GSA (Geological Society of America) Today, v. 7, p. 7-11.
Morton, R., and Gawboy, C., 2000, Talking Rocks: Geology and 10,000 Years of Native American Tradition in the Lake Superior Region, Duluth, Minnesota, Pfeifer-Hamilton Publishers, 213 p.
Mullens, A., 2001, Why Aboriginal students aren't taking science, University Affairs, November, p. 8-11 and 17.

Murray, J.J., 1997, Ethnogeology and its implications for the Aboriginal geoscience curriculum, Journal of Geoscience Education, v. 45, p. 117-122.

Nations, D., and Stump, E., 1996, Geology of Arizona (2nd edition), Dubuque, Iowa, Kendall-Hunt, 260 p.

Nelson-Barber, S., and Estrin, E.T., Bringing Native American perspectives to mathematics and science teaching, Theory into Practice, v. 34, p. 174-185.

Ogunwole, S.U., 2002, The American Indian and Alaska Native population, 2000, United States Census Bureau, Census 2000 Brief C2KBR/01-15, 12 p.

Orris, J., 2004, Integrating place-based education into elementary schools [M.S. thesis], Prescott (Arizona), Prescott College, 95 p.

Ortiz, S.J., 1992, Woven Stone, Tucson, University of Arizona Press, 365 p.

Pestrong, R., 2000, Your personal park, Journal of Geoscience Education, v. 48, p. 604.

Press, F., Siever, R., Grotzinger, J., and Jordan, T.H., 2004, Understanding Earth (4th edition), New York, W.H. Freeman and Company, 600 p.

Reynolds, S.J., Johnson, J.K., and Stump, E., 2003, Observing and Interpreting Geology: a Laboratory Manual for Interpreting Geology (Fall 2003 edition), Tucson, Arizona, Terra Chroma, 194 p.

Rhodes, R.W., 1994, Nurturing Learning in Native American Students, Hotevilla, Hopi Nation, Arizona, Sonwai Books, 217 p.

Riggs, E. M., 1998, Toward an understanding of the roles of scientific, traditional, and spiritual knowledge in our "demon-haunted world," American Indian Culture and Research Journal, v. 22, p. 213-226.

Riggs, E.M., 2003, Global science literacy in an Indigenous context - a perspective from North America, in: Mayer, V., editor, Implementing Global Science Literacy, Columbus, Ohio, Ohio State University Press, p. 33-52.

Riggs, E.M., 2004, Field-based Earth science education and indigenous knowledge: essential components of geoscience education for Native American communities, Science Education, DOI 10.1002/sce.20032.

Riggs, E.M., and Semken, S.C., 2001, Earth science education for Native Americans, Geotimes, v. 46, p. 14-17.

Rock Point Community School, 1982, Between Sacred Mountains, Tucson, University of Arizona Press, 288 p.

Rossbacher, L., 2002, Geologic column: knowing a place, Geotimes, v. 47, p. 48.

Ryden, K.C., 1993, Mapping the Invisible Landscape: Folklore, Writing, and the Sense of Place, Iowa City, University of Iowa Press, 326 p.

Savoy, L.E., 1992, Encounters with the land, GSA Today, v. 2, p. 213, 216-218.

Schama, S., 1995, Landscape and Memory, New York, Vintage Books, 652 p.

Semken, S.C., 1997, NAGT/GSA symposium on geoscience education in Native American communities, Journal of Geoscience Education, v. 45, p. 104-105.

Semken, S.C., Goldtooth-Semken, C., and Luna, L., 1996, The geology underlying conflicts over Native American lands in the western United States [abstract], Geological Society of America Abstracts with Programs, v. 28, p. A-399.

Semken, S.C., and Morgan, F., 1997, Navajo pedagogy and Earth systems, Journal of Geoscience Education, v. 45, p. 109-112.

Semken, S., and Piburn, M.D., 2004, The meaning and measurement of sense of place for place-based geoscience teaching [abstract], Geological Society of America Abstracts with Programs, v. 36, n. 5, p. 555.

Shamai, S., 1991, Sense of place: an empirical measurement, Geoforum, v. 22, p. 347-358.

Smith, D.L., Hoersch, A.L., and Gordon, P.R., 1995, Problem-based learning in the undergraduate geology classroom, Journal of Geological Education, v. 43, p. 385-390.

Smith, L.T., 1999, Decolonizing Methodologies: Research and Indigenous Peoples, London, Zed Books Limited, 208 p.

Sobel, D., 2004, Place-Based Education: Connecting Classrooms and Communities, Great Barrington, Massachusetts, The Orion Society, 109 p.

Stedman, R.C., 2003, Sense of place and forest science: toward a program of quantitative research, Forest Science, v. 49, p. 822-829.

Stephens, S., 2000, Handbook for Culturally-Responsive Science Curriculum, Fairbanks, Alaska, Alaska Science Consortium and Alaska Rural Systemic Initiative, 40 p.

Suzuki, D., and Knudtson, P., 1992, Wisdom of the Elders: Sacred Native Stories of Nature, New York, Bantam Books, 275 p.

Tewksbury, B.J., 1995, Connecting the geology of Africa with the prehistoric, historical, political, and economic evolution of the continent as a strategy for teaching introductory geology and attracting minority students to geology, Journal of Geoscience Education, v. 43, p. 492-496.

Tuan, Y-F., 1977, Space and Place: the Perspective of Experience, Minneapolis, Minnesota, University of Minnesota Press, 235 p.

Williams, D.R., and Patterson, M.E., 1996, Environmental meaning and ecosystem management: perspectives from environmental psychology and human geography, Society and Natural Resources, v. 9, p. 507-521.

Williams, D.R., and Roggenbuck, J.W., 1989, Measuring place attachment: some preliminary results, Proceedings of the symposium on Leisure Research, National Recreation and Park Association, Alexandria, Virginia, p. 32.

Williams, D.R., and Stewart, S.I., 1998, Sense of place: an elusive concept that is finding a home in ecosystem management, Journal of Forestry, v. 96, p. 18-23.

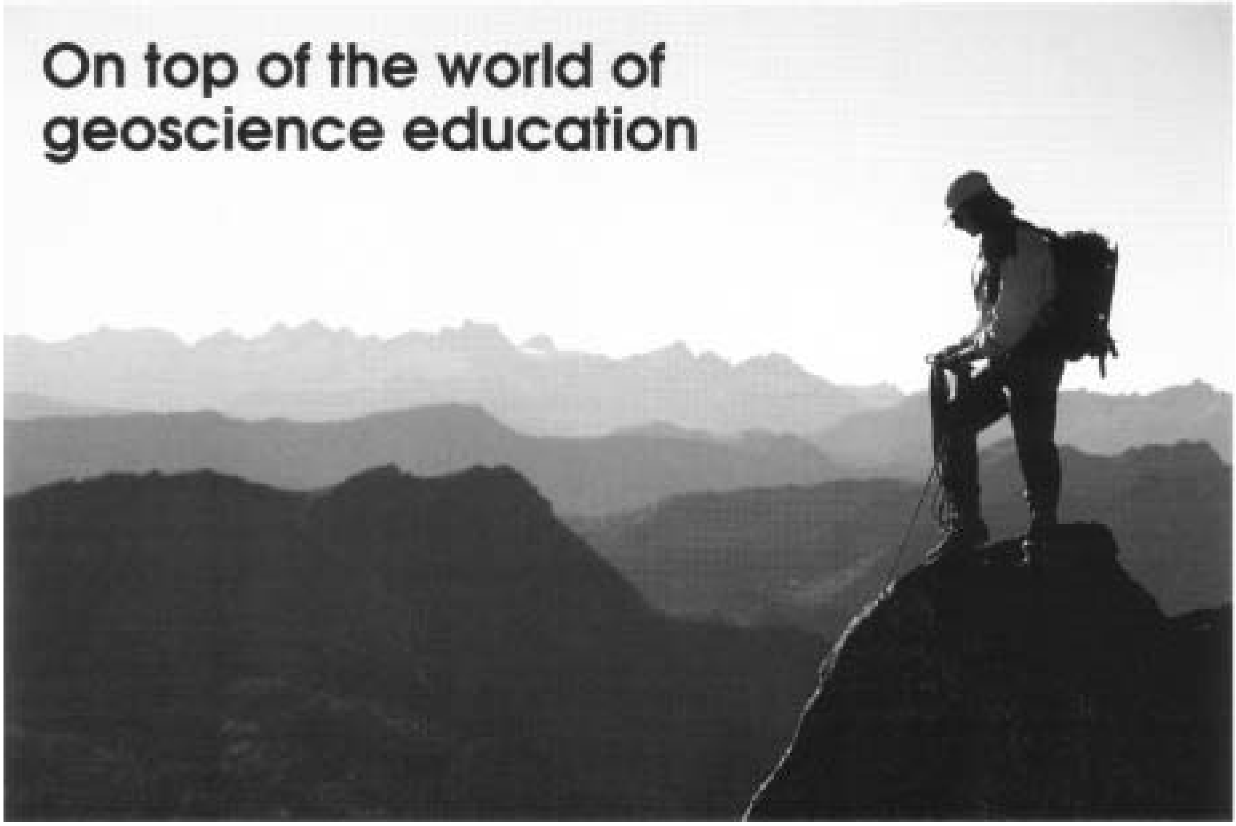
Williams, D.R., and Vaske, J.J., 2003, The measurement of place attachment: validity and generalizability of a psychometric approach, Forest Science, v. 49, p. 830-840.

Willink, R.S., and Zolbrod, P.G., 1996, Weaving a World: Textiles and the Navajo Way of Seeing, with photographs by Vavruska, J., Santa Fé, Museum of New Mexico Press, 120 p.

Woodhouse, J.L., and Knapp, C.E., 2000, Place-based curriculum and instruction: outdoor and environmental education approaches, Digest EDO-RC-00-6, Charleston, West Virginia, ERIC Clearinghouse on Rural Education and Small Schools, Appalachia Educational Laboratory, 2 p.

Zappo, L.E., 1998, A demographic survey relevant to Earth-science teachers as mentors and role models for minority students, Journal of Geoscience Education, v. 46, p. 368-373.

Zolbrod, P.G., 1984, Diné Bahane': the Navajo Creation Story, Albuquerque, University of New Mexico Press, 431 p.



Journal of Geoscience Education

Practical, creative, and innovative ideas for teaching geoscience

Name (print or type)________________________________Phone____________________
Mailing Address________________________________Fax____________________
____
City____________State______Country_________Postal Code__________
E-mail________________________________
____College/University Professor at________________________
____Pre-College Teacher at________________________
____Other at________________________

Individual Subscription & Membership Rates (US Funds)

Regular USA	$35	___
Outside USA	$47	___
Student* USA	$20	___
Student* outside USA	$32	___
Retired NAGT member	$30	___
Library Subscriptions		
Regular USA	$75	___
Outside USA	$87	___

____New ____Renewal

Checks (US funds only) are payable to National Association of Geoscience Teachers.
Mail to: NAGT, 31 Crestview Dr., Napa, CA 94558 USA

Please charge my credit card for my membership fees____Visa____MC
Credit Card #____________________Exp. Date______Signature____________________

The membership year runs from January through December, and members receive 5 issues of JGE per year. Subscriptions received after June 1 will begin receiving the Journal in January of the following year. Back issues are available for $15 each ($18 foreign).

*To qualify for student rate, indicate status below, and obtain verification from an NAGT member.
_____Undergraduate_____Graduate________________________________
Signature of NAGT member School

National Association of Geoscience Teachers