IN THIS ISSUE

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In The Trenches

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On the Cover: Pre-service Earth science teachers examine glacial striations in Central Park, Manhattan. (Photo by Matthew Garb)

At Right: (Photo by Erika Vye)

In the Trenches is a quarterly magazine of the National Association of Geoscience Teachers, a professional association that works to foster improvement in the teaching of the Earth sciences at all levels of instruction, to emphasize the cultural significance of the Earth sciences and to disseminate knowledge in this field to the general public. To learn more about *ITT*, visit <http://nagt.org/nagt/publications/trenches/index.htm>

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A SENSE OF THE AMERICAN SOUTHWEST

ESAS students walk through Southwest geologic history on the Trail of Time at Grand Canyon. (Photo by Steven Semken)

Place-Based Earth System Science for Diverse Students

People connect to their surroundings by means of ***places***, the myriad physical localities that we endow with diverse meanings by experiencing them, learning about them, caring for them, living in them, defending them and in other ways. Scientific study and interpretation are part of the human process of meaning-making that names and forms places in natural landscapes. But most places also hold cultural and other humanistic meanings and can inspire strong emotional responses and personal or communal feelings of attachment and stewardship. The meanings people find and make in a place and their affective relationships to that place (whether attachment, indifference or aversion) together constitute the ***sense of place***.

We teach and learn Earth science in and through places, whether directly through learning experiences in the field or the community or by making use of examples, materials or data collected from one place or another. Place also shapes Earth science education because Earth processes are locally as well as temporally contingent. What happens in one place differs from what happens in another. (Consider the global distribution of volcanism or a regional seismic "shakemap.") And events in a particular place can influence or indicate what happens later in the same place. (Envision a poorly placed roadcut prone to repeated mass movements.)

Authentically ***place-based*** science teaching and learning is distinguished from other situated approaches to science education such as field-based or problem-based teaching because it constructively leverages humanistic place meanings (Elder, 1998) *and* affective place attachments, i.e., sense of place (Semken and Butler Freeman, 2008), as engaging and relevant contexts for scientific inquiry and interpretation. Place-based teaching typically encompasses experiential learning in the field or neighborhood, a focus on Earth system processes and features that can be observed locally; integration of artistic, humanistic and multicultural ways of knowing place, e.g., sketching, journaling, photography, studies of literary and visual arts, interviews; engagement with environmental issues and cases of local importance; and service-learning projects. Studies of Earth system components and processes at increasingly fine scales,

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e.g., EarthScope Project/earthscope.org, and also at the grassroots level, e.g., GLOBE Program/globe.gov, constitute rich sources of locally situated scientific content for place-based teaching.

Ault (2008) characterizes place-based education as a continuum from the use of certain attributes of places as examples in a discipline-centered curriculum to a complete synthesis of disciplinary methods and ideas with place as the focus of inquiry. Models and case studies of curriculum and methods ranging across much of this continuum can be found in a growing literature on place-based education (e.g., Gruenewald and Smith, 2008; Smith and Sobel, 2010). Recent examples of place-based teaching applied specifically to Earth science include, but are hardly limited to, published work by Butler et al. (2001), Endreny (2010), McCoy (2011), Miele and Powell (2010), Palmer et al. (2009) and Semken (2005).

Advocacy, Outcomes and Assessment

Place-based education is advocated by its practitioners for its immediate relevance to students and its payback to stakeholders through support for environmental and cultural sustainability of places and a more locally aware and active citizenry (Smith and Sobel, 2010). It offers geoscience educators a means to engage and retain a broader cross-section of students, including those in underrepresented groups—whether because of their prior strong cultural and historic ties to particular places, e.g., Native Americans (Cajete, 2000) or because they abide in highly built, human-dominated places-such as major metropolitan areas (Endreny, 2010; Miele and Powell, 2010).

The efficacy of place-based teaching, in terms of student improvement in content and conceptual knowledge and other commonly expected outcomes, has been demonstrated in multiple studies (Semken and Butler Freeman, 2007; Endreny, 2010). Many published case studies describe benefits to schools and communities that are only obtainable using a place-based approach (Gruenewald and Smith, 2008; Smith and Sobel, 2010).

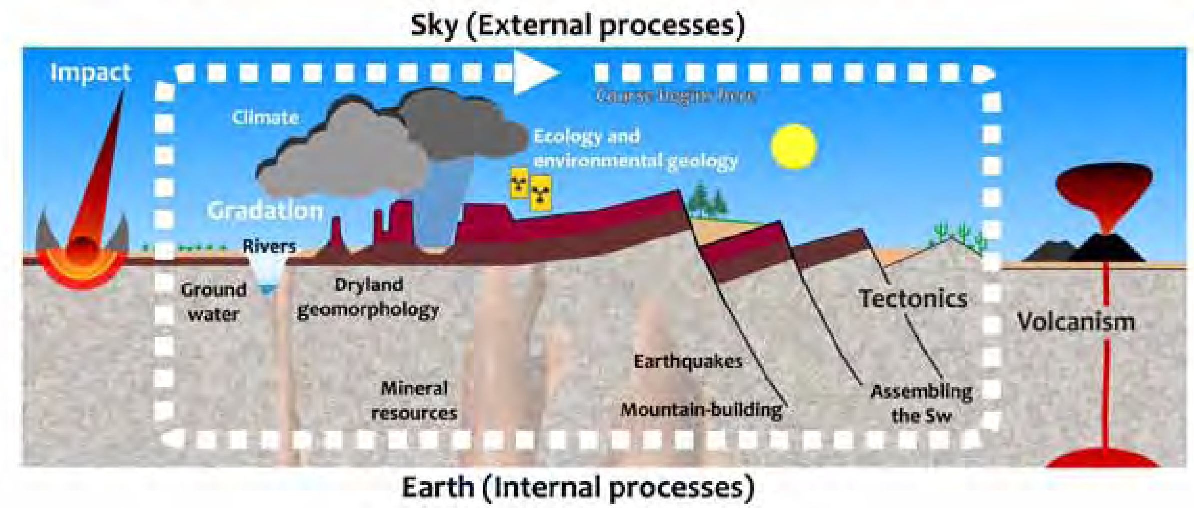
Sense of place, which has a rich theoretical basis in geography and environmental psychology, should also be considered an expected and measurable learning outcome of place-based teaching. Enhancement of students' senses of the places under study—the meanings and attachments they develop—can also be assessed, both quantitatively using published surveys (Semken and Butler Freeman, 2008) and qualitatively with ethnographic methods that include interviews, direct observations and analyses of student artifacts such as assignments and projects (Endreny, 2010; Williams and Semken, 2011).

"Earth Science in Arizona and the Southwest"

A place-based undergraduate Earth system science course (Geology 301, "Earth Science in Arizona and the Southwest" or ESAS) is now offered regularly at Arizona State University (ASU). ESAS is informed by theories of place and place-based learning, by integrated geoscientific, ecological and humanistic knowledge of the American Southwest and by the results from assessment of three pilot offerings of the course off- and on-campus (Semken and Butler Freeman, 2007; 2008; Williams and Semken, 2011).

ESAS serves an academically and ethnically diverse mix of Earth and space science education majors (pre-service teachers, for whom the course is required) and non-majors. The broad range of student backgrounds and interests is fully concordant with the philosophy of place-based education. Geoscience majors, expected to be familiar with some of the course content, can enroll in ESAS if they agree in writing to serve actively as peer instructors during in-class cooperative learning activities. The course is one of only a few in the current ASU geoscience program that meet the criteria for a graduation requirement in "science and society": "Students must demonstrate understanding of, and critically evaluate, the reciprocal relationships among scientific inquiry and the functions of society." The criteria are met as ESAS students investigate the dynamics of Earth and human systems in locally important issues of water availability and quality, land use and development, mineral and energy resource extraction and environmental justice. These case studies often form the basis for service-learning projects such as community presentations or web-hosted resources, which are also required of all ESAS students. Up to 75 students can enroll in each offering of the course.

The overarching goals of ESAS are cognitive and affective: (1) to improve knowledge of Southwestern geology, hydrology, climate and ecology according to a student's needs (such as, a regional survey for Earth science pre-service teachers or locally situated Earth science literacy for non-majors who wish to be better informed Southwest citizens; (2) to richly demonstrate the reciprocal relationships among scientific inquiry and Southwest society; (3) to promote and facilitate lifelong learning in and about the Southwest; and (4) to leverage and enhance students' senses of place by actively encouraging greater familiarity with Southwestern lifeways and stronger personal attachment to the region.



The curriculum is organized under the broad themes of rock, water, air and life systems and of interactions between Earth (internal processes) and sky (external processes) as they form and sculpt the distinctive landscapes of the Southwest. These interrelationships are depicted graphically in the diagram above.

This conceptual scheme bridges mainstream Earth system science and indigenous Southwestern ethnoscience and was piloted in a predecessor course, "Indigenous Physical Geology," developed by the author at the tribal college of the Navajo Nation (Semken, 2005). It is presented to ESAS students as a fifteen-week journey. Principal topics include regional physiography and its influences on ecosystems and human habitation, Proterozoic to Holocene geologic evolution of the Southwest, Cordilleran orogenies, life-cycle analyses of ore deposits, dryland hydrology and geomorphology, the Colorado River basin and Southwestern water projects, the energy-water nexus and dryland eolian processes in the context of climate change. Learning outcomes for ESAS are based on the *Earth Science Literacy Principles* (Earth Science Literacy Initiative, 2009) but are focused on those Earth-system features and processes most prominent in the desert and mountain Southwest.

ESAS meets twice weekly for 75-minute interactive lectures, taught as two or three learning cycles in which an exploratory exercise such as image interpretation, concept sketching or back-of-the-envelope calculation precedes a short explanatory presentation. Most students in a large-enrollment, principally non-major course have logistical, financial or family circumstances that limit their capacity to take extramural field trips. Field activities in ESAS are done locally in desert parks and preserves on weekend mornings, taking advantage of wide expanses of protected open landscape in metropolitan Phoenix. Students are encouraged, but not required, to attend all of these half-day trips. An optional weekend excursion to Grand Canyon (at a student's own expense), with stops en route, captures most of Arizona's geologic history and and exposes students to modern environmental Earth science.

As instructional technology is upgraded in ASU classrooms, we are making increasing use of digital tools such as Google Earth and Gigapan to conduct virtual field exercises in geologically interesting Southwestern localities.

An explicit learning goal of ESAS is to leverage and enhance every student's sense of place, whether he or she is native to the region or not. This goal is met in several ways, the most pervasive of which is the exclusive use of local landscapes and environments to illustrate Earth science principles and geologic history. ESAS also integrates locally situated, multicultural ways of naming, describing and understanding Earth systems and processes. It includes representations of hydrologic and geomorphic processes in Southwest Native American philosophy and art, as well as liberal use of Native American and Hispanic terminology and place names. For example, students investigate the North American summer monsoon—an indispensable annual source of rain—not only as a regional climatic process, but in the context of the historical significance of the monsoon to regional cultures, its representation in many forms of Southwest art, e.g., Navajo storm-pattern rugs and magazine photographs of clouds and lightning, and its current impact on local communities, e.g., a "stupid motorist" law motivated by Arizonans who ignore warnings and drive into flooded arroyos. Sense of place is further leveraged and enriched as students apply Earth science, critical thinking, personal experience and opinion to analyze current environmental and economic issues of local and regional relevance, e.g., water and energy availability, sprawl, and copper mining versus wilderness preservation.

Efficacy and Impact of ESAS

From its inception, ESAS has also served as a testbed for research on place-based undergraduate teaching and K-12 teacher professional development. Mixed-methods assessment of the first three offerings of the course revealed significant gains in Earth science content knowledge and sense of place (Semken and Butler Freeman, 2007; 2008). Additionally, a majority of participating in-service teachers reported positive responses to the place-based approach, including a richer sense of place, enhanced comprehension of Earth system science—even among non-science teachers—and the use of more place-based, relevant and metacognitive classroom teaching (Williams and Semken, 2011). Additional studies of place-based learning involving ESAS are ongoing.

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