Sense of Place in the Practice and Assessment of Place-Based Science Teaching

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ABSTRACT: We teach earth, ecological, and environmental sciences in and about *places* imbued with meaning by human experience. Scientific understanding is but one of the many types of meanings that can accrue to a given place. People develop emotional attachments to meaningful places. The *sense of place,* encompassing the meanings and attachments that places hold for people, has been well characterized in environmental psychology. Its components, place attachment and place meaning, can be measured psychometrically. *Place-based* science teaching focuses on local and regional environments and synthesizes different ways of knowing them, leveraging the senses of place of students and teachers. Place-based teaching has been advocated for its relevance and potential to attract underrepresented groups to science. We posit that sense of place is a measurable learning outcome of place-based science teaching. We developed an Arizona-based, culturally inclusive, meaning-rich introductory geology course, and used published surveys to assess place attachment and meaning in students who took the course. We observed significant gains in student place attachment and place meaning, indicating that these instruments are generalizable and sensitive enough for use in this context. Sense of place should be engaged by teachers of place-based science, and further explored as an assessment measure.
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INTRODUCTION

The earth, ecological, and environmental sciences are taught in and by means of physical localities in nature that are also *places* imbued with meaning by human experience (Tuan,

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1977). The *sense of place* is a term used liberally but often differently in humanistic, sociological, geographic, and educational discourse (e.g., Feld & Basso, 1996; Kincheloe, McKinley, Lim, & Calabrese Barton, 2006; Ryden, 1993; Williams & Stewart, 1998) to encapsulate connections among people and places.

Places are socially constructed out of physical spaces (Tuan, 1977), and sense of place has been described by Steele (1981) as "created by the setting combined with what a person brings to it" (p. 9). Many different meanings—for example, aesthetic, ceremonial, economic, familial, historical, political, and spiritual, as well as scientific—can accrue to the same place, evincing the spectrum of ways that individuals and communities know and experience it. People also develop emotional attachments to meaningful places. The combined set of place meanings and place attachments, held by a person or a group, constitutes a functional definition of the sense of place (Brandenburg & Carroll, 1995; Williams & Stewart, 1998). Because it is characterized by relationship to some identifiable portion of the coincident natural and cultural landscapes, sense of place is contextually bound, much like the overlapping concept of indigeneity (McKinley, 2007). However, these landscapes evolve, contextual boundaries are redefined, and sense of place is socially negotiated (Casey, 1996).

Sense of place has become a commonly used factor in land and resource management (Kruger & Jakes, 2003; Williams & Stewart, 1998) and in community planning and design (Bott, Banning, Wells, Haas, & Lakey, 2006). These applications require means of measuring sense of place, and led to the development of psychometric instruments that will be discussed in detail below. Considered from the perspective of teaching and learning, sense of place defined as place meaning plus place attachment encompasses the cognitive (knowledge as place meaning) and affective domains (place attachment; attitudes and preferences as place meanings). It may also extend into the psychomotor domain by incorporating kinesthetic skills learned or performed in specific physical places, whether for avocational (e.g., playground leisure: Lim & Calabrese Barton, 2006) or vocational (e.g., tilling a field) purposes.

PLACE-BASED EDUCATION

Globalization, careerism, standards-based education, entertainment media, and even well-intentioned advocacy for environmental and humanitarian concerns in distant parts of the globe (e.g., Amazon Basin rainforests) divert people from meaningful interactions with nearby places (Gruenewald, 2003a, 2003b; Meyrowitz, 1985; Sobel, 1996). For many Americans, notably children and their parents, personal intimacy with the surrounding environment has been supplanted by misunderstanding, fear, and avoidance of nature (Sobel, 1996); possibly even to the detriment of their physical and mental health (Louv, 2005). Furthermore, to have little or no sense of local places is to be oblivious to their aesthetic value and their cultural and political significance, and possibly even to accede to their environmental or social degradation. This is a perilous path, in light of the increasing cultural diversity of our school population and mounting public concern over the sustainability of lifeways in the developed world.

In contrast, the many dimensions of human experiences in places have been shown to be "profoundly pedagogical [in] nature" (Gruenewald, 2003b, p. 1). Hence "place-based" or "place-conscious" education (Gruenewald, 2003a, 2003b; Gruenewald & Smith, 2008; Smith, 2002; Sobel, 2004; Woodhouse & Knapp, 2000), a situated method that variously encompasses:

- experiential learning in and about local or regionally characteristic (i.e., authentically representative of the encompassing region) natural and social settings;

- transdisciplinary and cross-cultural synthesis of place-related knowledge and pedagogy; and
- service learning or other forms of community outreach.

Place-based teaching is conscious of, and intentionally leverages (Lim & Calabrese Barton, 2006; Semken, 2005) the senses of place of students and instructors; and promotes local ecological and cultural sustainability over competitiveness and resource exploitation (Sobel, 2004).

PLACE-BASED SCIENCE TEACHING AND DIVERSITY

In the natural sciences, place-based pedagogy is advocated as a way to improve engagement and retention of students, particularly members of indigenous or historically inhabited communities (e.g., American Indian, Alaska Native, Native Hawaiian, Mexican American) who possess rich culturally rooted senses of the places studied (Aikenhead, Calabrese Barton, & Chinn, 2006; Cajete, 2000; Emekauwa, 2004; Gibson & Puniwai, 2006; Kawagley, D. Norris-Tull, & R. A. Norris-Tull, 1998; Riggs, 2005; Semken, 2005). The knowledge systems these groups have built over centuries or millennia of observation, reasoning, and intergenerational transfer are variously called traditional ecological knowledge (Inglis, 1993), local environmental knowledge (Reynolds et al., 2007), or simply indigenous or local knowledge (Riggs, 2005). These are of increasing interest to the mainstream scientific community (Couzin, 2007; Krajick, 2005) and are making their way into science teaching as well (Aikenhead, 1997, 2001; Cajete, 1994; Chinn, 2006; Glasson, Frykholm, Mhango, & Phiri, 2006; Nelson-Barber & Estrin, 1995; Riggs & Semken, 2001; Semken, 2005; Semken & Morgan, 1997; Snively & Corsiglia, 2001).

Science curricula and methods that dispassionately probe and analyze places that are meaningful to these underrepresented students, or represent them in ways that are culturally inappropriate or offensive—for example, portraying planet earth as a machine (Semken, 2005) or the environment as a repository for wastes (Chinn, 2006)—may contribute to cultural discontinuity that deters them from scientific study and careers (Aikenhead & Jegede, 1999; Semken, 2005). Thus conscientious, effective place-based science teaching must be informed not only by the sound scientific knowledge of the places of study (such as would underpin any good mainstream pedagogy) but also by a respectful if not mutual understanding of the diverse meanings and attachments affixed to these places. These meanings and attachments provide context for the scientific knowledge, and enrichment of the senses of place of students and instructor should be an expected learning outcome of a place-based science lesson, course, or curriculum (Semken, 2005).

HOW CAN WE TEACH SENSE OF PLACE IN A SCIENCE CLASS?

Authentic place-based education is experiential and transdisciplinary. It is clearly suited to educational settings and systems that afford plenty of access to the outdoors and the community, and to teaching schedules that allow time for exploration and synthesis of place meanings. Sobel (2004) has reviewed a range of established place-based educational programs, situated in geographically widespread places and mostly at K-12 schools. Place-based teaching is less commonly practiced at the college level, where experimental course offerings are often pinioned by tight schedules and the host of academic, economic, and personal demands on a 21st-century undergraduate's time. Here may be missed opportunities not only to engage and recruit more diverse students into science but also to nurture place-conscious teaching skills and build interdisciplinary expertise in preservice science teachers.

What scientific subjects lend themselves best to a place-based approach? Gruenewald (2003b) argues for the revival of natural history: a field-based, descriptive synthesis of earth sciences, botany, and zoology that was most popular among educators in the early part of the last century. Butler, Hall-Wallace, and Burgess (2000) developed and piloted a natural history seminar, based on the geology and ecology of the Tucson, Arizona area, and intended primarily for first-year undergraduates and local in-service teachers. The seminar was organized around four weekend field trips and focused on developing observational and interpretative skills.

Our challenge was to infuse the transdisciplinary, cross-cultural place-based philosophy into the introductory physical geology course offered regularly at our university and similar institutions, typically to large classes of 100 students or more. The same course is also offered by community colleges in our region, in class sizes of 50 or fewer, and credit for completion is readily transferred to any of the universities in our state. This physical geology course satisfies a general-education requirement for graduation and serves an academically and ethnically diverse student population, many of whom are elementary or secondary education majors, but few of whom have chosen to major in geoscience. At our university, it meets for three 50-minute or two 75-minute sessions each week in a lecture hall or classroom, and it is offered separately from the physical geology laboratory course. Because these constraints of enrollment and scheduling are unlikely to change soon, our place-based version of this course differed from its standard equivalent mostly in content and its organization, rather than in class hours, means of delivery (interactive lectures), or means of assessment (periodic exams).

Our place-based course was adapted from an "Indigenous geology" course developed in the mid-1990s at the tribal college of the *Diné* (Navajo) Nation (Semken, 2005; Semken & Morgan, 1997). The framework for that course was a dualistic ethnogeologic paradigm from the traditional knowledge of the Diné people, which describes natural processes of change as interactions between a dynamic Mother Earth and Father Sky (Semken & Morgan, 1997). The syllabus was organized as a cyclical intellectual path from the earth's surface (as encountered within *Diné bikéyah,* the homeland of the Diné, bounded by four sacred mountains at the heart of the high-desert province geoscientists now refer to as the Colorado plateau); downward through rocks and internal processes of the solid earth; to near-surface interactions between the solid earth and the sky (i.e., the fluid earth: climate and hydrology); and finally to external processes operating within and from the sky itself, including extraterrestrial impacts. Students used explanatory terms, scientific concepts, and place names drawn from indigenous Diné knowledge (e.g., Blackhorse, Semken, & Charley, 2003) in parallel with Western knowledge, and were encouraged to leverage their own knowledge of meaningful local places in class discussions and assignments.

In place-based teaching, the most important senses of place to consider are the personal meanings and attachments that exist between each student and the place or places offered as the context for the curriculum. Generalizability of the concept of sense of place across differently contextured places (e.g., *Diné bikéyah* versus metropolitan Phoenix) requires that any student be able to find meanings in and form attachments to the natural and cultural settings that are presented. No student, whether a native or a newcomer, should feel disengaged or marginalized by the selection and characterization of the place. Therefore, to more equitably engage the diverse student population at our large Arizona university and recenter the curriculum in a more proximal geography, we situated our new course in a place we identified as "Arizona." We chose this name for our study place after considering several others, because all of the students, having enrolled in the university and the course, could be identified at least for this time period as Arizonans. However, we explicitly presented "Arizona" not as a politically defined state, but as a complexly evolved and

ruggedly beautiful desert-mountain physical landscape and a multicultural, deeply historic, but rapidly urbanizing cultural landscape in the midst of the Southwest United States. We repeatedly expressed this conceptualization of Arizona to the students in the course. The physical landscape is comparable in areal extent and physiography to *Diné bikéyah,* and overlaps part of it; but the cultural landscape is considerably more diverse (McNamee, 1993). We were challenged to find and employ meanings such as place names and narratives from various cultures in proportion to their occurrence across the whole of Arizona.

We retained the cyclical path through earth and sky (internal to external natural processes) as the organizational framework of the course, because this is a theme common to many indigenous worldviews (Williamson & Farrer, 1992). Our syllabus comprised 12 modules on aspects of geology, hydrology, climate, and environmental quality relevant to Arizonans, and organized just as they would be encountered along the earth-to-sky cycle. The modules were situated in real places within the physical and cultural landscapes. The lead author's research, teaching, and recreational experiences in the region, and fervent attachment to many of the study places, informed the design and seasoned the presentation of the course. Student evaluations at the end of the course indicated that the instructor's enthusiasm for these places helped many students remain interested and engaged throughout the semester.

One key difference from the Diné course was our limited ability to conduct field trips; the schedule allowed for only three 2-hour inquiry field trips to nearby parks, where interesting rock bodies and active processes of change were readily observed. Although optional, the trips offered extra credit and thus were well attended. In lieu of regular access to the outdoors, we rendered the interior learning environment as evocative of the natural and cultural landscapes of Arizona as possible. Students handled, examined, and described sets of local rock, mineral, fossil, and soil samples. Visual materials such as PowerPoint slides, Web pages, and handouts emphasized landscape photographs, maps, and interpretative "concept sketches" (Johnson & Reynolds, 2005) over plain text. We made a point of commenting on the beauty of these Arizona places, as well as their scientific significance, and referred to them as much as possible by their American Indian, Spanish, and English place names. To enrich place meanings, we liberally offered evocative quotations and passages from the poetry and prose of authors such as Edward Abbey, Keith Basso, Craig Childs, Joy Harjo, Simon Ortiz, and Ann Zwinger. We sought to stimulate attachment to Arizona by means of current and affectively fraught case studies of local importance, including the environmental and public health impacts of Cold War era uranium mining on American Indian lands (Eichstaedt, 1994); coal mining and power generation in rural areas for the benefit of urban Arizona, and its potential effects on climate; control and overuse of the Colorado River system, the primary regional source of drinking water; and local and regional changes to water supplies, soils, and vegetation wrought by an ongoing, multiyear drought. Students reviewed and discussed the geological context and social implications of these cases.

The lead author of this paper taught, and the second author served as graduate teaching assistant for, the pilot offering of the experimental Arizona-based course in the fall semester of 2005. This initial class served as the setting for a preliminary study of changes in sense of place as cognitive and affective learning outcomes of place-based science teaching. In the next section, we present a theoretical and methodological framework for this study.

HOW CAN WE ASSESS THE TEACHING OF SENSE OF PLACE?

Thus far the literature on place-based education (a digital library is under development; Center for Place-Based Learning and Community Engagement, n.d.) has offered mostly advocacy, case studies, and teaching resources, but little research on effectiveness. Four

published studies are noted here:

- In a meta-analysis of 40 environment-based school programs across 12 states, which included 14 head-to-head comparisons with traditional decontextualized programs, Lieberman and Hoody (1998) reported that teaching that uses the environment as an organizing context significantly improves scores on standardized achievement tests in language arts, mathematics, science, and social studies, and fosters enthusiasm for problem solving and learning.
- Julie (Athman) Ernst and Martha Monroe found that environment-based teaching significantly improved achievement motivation (Athman & Monroe, 2004), and critical thinking skills and disposition toward critical thinking (Ernst & Monroe, 2004), in a study population of 400 Florida high school students.
- Powers (2004) reported on an external evaluation of four place-based education programs and identified a number of positive impacts on teacher practice, including richer use of local resources in teaching, more interdisciplinary teaching, enhanced collaboration among teachers, and more frequent use of community-based service learning projects.

These outcomes are important, but they do not indicate how deeply students have engaged with their physical and cultural environments, which is a defining characteristic of place-based teaching and a prominent motivation for employing it. If sense of place is environmentally and socially constructed and negotiated (Ryden, 1993; Casey, 1996; Stedman, 2003b), it must be a significant component of what students learn about places. We, therefore, posit that sense of place should be enhanced by place-based teaching; and if possible, measured as an authentic assessment of the teaching method. The means of characterizing and measuring sense of place in educational contexts, in terms of its two principal components place attachment and place meaning, emerge from the disciplines of environmental psychology and rural sociology.

CHARACTERIZING AND MEASURING PLACE ATTACHMENT

Place attachment refers to an affective bond formed through direct experience in, or vicarious engagement with, a place. Such bonds vary in intensity as well as duration. Shamai (1991) proposed a 7-point ordinal scale of place attachment extending from obliviousness (no sense of place), through knowledge of being in a place, belonging to a place, attachment to a place, identifying with goals of the place, involvement in a place, to willingness to make sacrifices for a place. Shamai tested the middle five elements of the scale (as the lowest and highest did not apply to his respondent population) in an empirical study of attachment to city, province, and nation in Jewish high school students in Toronto. All three of the place-attachment variables were found to be positively correlated with each other, indicating that attachments to places that are politically or geospatially "nested" may reinforce each other (Shamai, 1991). Kaltenborn (1998) successfully applied Shamai's scale to examine the relationship of place attachment to environmental perceptions and response to environmental changes in a group of inhabitants of the Svalbard archipelago of Norway. Both of these early studies were cast as quantitative surveys of sense of place, but more accurately measured its subordinate component, place attachment. More importantly, Shamai and Kaltenborn each demonstrated that place attachment can be quantitatively measured and compared among different groups of people.

For a place-attachment measure to have utility in an educational context, it should be generalizable across diverse places and study groups. Shamai (1991) and Kaltenborn (1998)

obtained good results from nearly identical surveys in two geographically and culturally different settings, which suggests but does not rigorously demonstrate generalizability of the instrument. Daniel Williams and colleagues (Williams, Patterson, Roggenbuck, & Watson, 1992; Williams & Vaske, 2003) specifically addressed questions of generalizability and validity in their development of a concise place-attachment measure. The design of this instrument is rooted in a theoretical model from environmental psychology that subdivides place attachment into two dimensions: *place dependence* and *place identity* (Brown, 1987; Williams et al., 1992). Place dependence is a functional attachment associated with the capacity or potential of a place to support the needs, goals, or intended activities of a person (Stokols & Shumaker, 1981; Williams & Vaske, 2003). Place identity is an emotional attachment to place (Korpela, 1989; Proshansky, 1978; Proshansky, Fabian, & Kaminoff, 1983; Williams & Vaske, 2003), comprising the "memories, ideas, feelings, attitudes, values, preferences, meanings, and conceptions" (Proshansky et al., 1983, p. 59) of and toward places that are part of a person's self-identity.

Williams and Vaske (2003) analyzed data from two-dimensional Likert-scale surveys of place attachment that they and their colleagues administered to a total of 2,819 respondents at four public-lands recreation sites in Colorado, two national parks in Virginia, and on the campus of the University of Illinois. They confirmed construct validity by means of a factor analysis indicating that their data best fit the two-dimensional theoretical model, and convergent validity as significant positive correlations among place dependence or place identity and theoretically related variables (frequency of visitation, familiarity, and identification of the place as "special" to the respondent). Using statistical methods based in generalizability theory (e.g., Cronbach, Gleser, Nanda, & Rajaratnam, 1972), Williams and Vaske demonstrated that an instrument with as few as six place-dependence items and six place-identity items was highly generalizable (coefficients .924 and .869, respectively) across diverse places, and that additional items yield little improvement in generalizability. They also reported good internal-consistency reliability (Cronbach's alphas ranging from .81 to .94) for the final 12-item survey (Table 1) across all seven of the study places. We adopted this valid, reliable, and generalizable instrument verbatim to measure student place attachment in a preliminary study discussed below. We refer to it as the *Place Attachment Inventory* (PAI).

TABLE 1
Place Attachment Instrument of Williams and Vaske (2003)

1. I feel (place name) is a part of me.
2. (Place name) is the best place for what I like to do.
3. (Place name) is very special to me.
4. No other place can compare to (place name).
5. I identify strongly with (place name).
6. I get more satisfaction out of visiting (place name) than any other.
7. I am very attached to (place name).
8. Doing what I do at (place name) is more important to me than doing it in any other place.
9. Visiting (place name) says a lot about who I am.
10. I wouldn't substitute any other area for doing the types of things I do at (place name).
11. (Place name) means a lot to me.
12. The things I do at (place name) I would enjoy doing just as much at a similar site.

Note. The odd-numbered items measure place identity, the even-numbered items measure place dependence, and the final item is reverse scored.

CHARACTERIZING AND MEASURING PLACE MEANING

Stedman (2003a) observes that quantitative research on sense of place has been focused on place attachment and neglected the dimension of place meaning: "Researchers ought to examine not just *how much* the place means... but *what* does it mean?" (p. 826). The characterization of place meaning and the development of psychometric instruments to measure it have lagged. This is probably because place meaning is more localized than place attachment, and because potential sources of meaning for any given place may too numerous and diverse to encompass. Young (1999) empirically derived a place-meaning survey for a tropical World Heritage parkland region in northeast Queensland, Australia. Young's approach assumes that place meanings are socially constructed and negotiated between those who "produce" or disseminate meanings, such as tour guides and interpretative specialists; and those who "consume" (hold or construct) meanings, such as tourists. (In the context of place-based education, teachers might be considered "producers" and students "consumers," although in the collaborative atmosphere ideally fostered by the method, a more bidirectional exchange of place meanings is desired.) Young constructed his instrument by synthesizing place meanings from two sources: textual analysis of brochures provided by 65 commercial tour operators for "produced" meanings, and 54 semistructured interviews of 74 visitors (some were in family groups) in the parks for "consumed" meanings. The most common emergent themes from both populations were condensed into a list of 30 place-meaning items (Table 2).

In a subsequent study of subjective influences on the meanings of tourist places, Young presented these 30 items to respondents ($n = 1000$) as a questionnaire with a 5-point scale, by which each item can be rated as a poor, fair, good, very good, or excellent description of the place.

Young (1999) did not discuss validity or reliability of this instrument. We deemed this survey to be valid for measurement of place meaning in individual respondents on the basis of Young's theoretical model for construction of place meaning, which is analogous to the models of other place theorists (Casey, 1996; Ryden, 1993) and, as noted, is relevant to a place-based educational context. Young's naturalistic, empirical construction of place-meaning items from local sources also affirms the validity of these items (Aikenhead &

TABLE 2
Place Meaning Survey of Young (1999)

Ancient	Ecologically important
Pristine	Fun
Scenic	Threatened
Beautiful	Crowded
Remote	Dangerous
Unique	Interesting
Important to preserve	Educational
Authentic	Tranquil
Privilege to visit	Spiritually valuable
Relaxing	Fragile
Important for Aboriginal culture	Wilderness
Overdeveloped	Historical
Tropical	Exotic
Unusual	Adventurous
Scientifically valuable	Comfortable

Ryan, 1992; Vázquez, Manassero, & Acevedo, 2006). We note that nearly all of the items are sufficiently generic as to be applicable to the physical and cultural landscapes of Arizona and the Southwest United States.

Empirically derived quantitative instruments such as this are intended to synthesize the richness of an interpretative data set with the efficiency of a quantitative survey, which enables the rapid collection of large samples and the direct application of statistical analyses to the results (Aikenhead, 1988). The hazard in this approach, particularly relevant to the assessment of any complex and highly subjective concept such as sense of place, is that the subjective richness of the content encoded in the items may not be accurately represented by the numerical scale imposed by the researcher (Vázquez et al., 2006). For example, a "4" on Young's (1999) scale, which is proposed to indicate that a particular place-meaning item is a "very good" description of a place, could be understood quite differently by a respondent and the researcher. Vázquez et al. (2006) have proposed that the validity of such instruments can be enhanced by enabling respondents to express a level of agreement with each of a small set of statements that variously describe each item being assessed. To enable meaningful quantitative analysis of the results, the range of responses to each statement can be scaled by a panel of experts (Vázquez et al., 2006). For place meaning, such an expert panel might consist of a representative sampling of the stakeholders in the place of interest: those who inhabit, study, develop, promote, visit, or in some way value it. This level of synthesis was beyond the scope of our preliminary study.

We suggest that the question of construct validity raised here is most relevant to the use of Young's (1999) instrument as an *absolute* measure of the meanings a place holds for a respondent. The use of this survey as an assessment device for a place-based course entails administration of the identical instrument to the same set of students before and after the course. We posit that each student's perception of the 5-point scale will be the same or similar for the presurvey and the postsurvey, and hence the result will be an acceptable measure of a *relative* change in place meaning. We adopted Young's instrument and refer to it as the *Place Meaning Survey* (PMS).

PRELIMINARY ASSESSMENT OF PLACE-BASED SCIENCE TEACHING

We used the PAI and PMS in a preliminary test of the sensitivity of these published psychometric instruments as assessment tools for place-based science teaching. Our intent was to look for changes (ideally, gains) in student place attachment and place meaning as outcomes of the pilot experimental Arizona-based geology course in the fall 2005 semester at our university. This preliminary study was guided by two research questions directly related to sense of place:

1. Can significant changes in place attachment and place meaning be discerned in student populations such as our experimental group?
2. Does place-based teaching enhance students' attachment to places, and enrich the set of meanings these places hold for them?

Thirty-one students (13 female and 18 male) were selected randomly from a list of volunteers who had originally enrolled in one of the conventional large-lecture sections of the course. Of these students, 26 identified themselves as White, 2 as American Indian, 1 as Pacific Islander, and 3 as Hispanic, with some selecting more than one designation. When asked to identify the place they considered to be their home, regardless of where they were then residing, 22 students named communities in Arizona, and the other 9 named communities in other U.S. states. This distribution was very similar to that of

the aggregate undergraduate population at our university in the fall of 2005. None of the student participants had taken a prior college-level geoscience course, or any course we taught previously, and none had declared a major in geology. Before the Arizona-based course met for the first time, the students were told only that it would yield the same course credit as would a conventional large-lecture section, but would be experimental and require participation in surveys. They were not informed in any way about the place-based nature of the course until after they took the pretests.

METHOD

The PAI and PMS were administered as pretests and posttests, at the start of the first day of class and at the end of the final day. In both instruments we identified the place as Arizona. Although 31 students initially registered for the course, 4 dropped out at different points in the semester, so 27 students took both the pretests and the posttests. It was only logistically possible to offer one section of the experimental course, so control groups were not available for this study. However, we also had access to a much larger set of PAI data obtained at the close of several conventional sections of the course ($n = 753$) for a concurrent study of place attachment versus student demographics (Semken & Piburn, 2004; Perkins & Semken, 2008). We used these data as a comparison set.

As did Williams and Vaske (2003), we posed the six place-dependence items and six place-identity items on the PAI in alternating order. The students were asked to rate each statement on a 5-point Likert scale with 1 corresponding to "strongly disagree," 2 to "disagree," 3 to "neutral," 4 to "agree," and 5 to "strongly agree." The sixth place-dependence item, "The things I do at (place name) I would enjoy doing just as much at a similar site," is negative and was, therefore, reverse scored. A total PAI score from 36 to 60 indicates place attachment, whereas a score below 36 indicates place aversion.

For the PMS, we used 28 of the 30 items from Young's (1999) survey, eliminating "tropical" (not applicable to the setting), "fun," and "comfortable" (which we deemed too touristic). We changed one item, "important for Aboriginal culture," to "important for Native American culture." Students were asked to rate the 28 items for applicability to Arizona using the 5-point scale of Young (1999). The items "overdeveloped," "dangerous," "crowded," and "threatened" represent degradation of Arizona and were reverse scored. Agreement with any of the other 24 items indicates that Arizona holds that particular affirmative place meaning for the respondent. The minimum PMS score of 28 indicates that Arizona holds very little meaning for the student, whereas a score approaching the maximum of 140 indicates that Arizona holds diverse, rich, positive meanings for the student.

FINDINGS

Place Attachment

Results from the PAI paired prepost comparison (Table 3) show a gain in mean student PAI score, signifying an increased place attachment to Arizona, from immediately before the Arizona-based course to immediately after it. The mean pretest and posttest scores indicate, respectively, mild and moderate place attachment to Arizona. The mean PAI posttest score for students in the Arizona-based course was also greater than the mean PAI posttest score for the non-place-based comparison group, students enrolled in the conventional course at our university.

Using a non-directional-dependent samples t test (in the SPSS statistical software package; results presented in Table 4), we found this gain to be significant, $t(26) = 2.94$,

TABLE 3
Comparison of Mean PAI Scores for Students in the Arizona-Based Course and Students in the Conventional Geology Course

	n	Mean Score	Standard Deviation	Standard Error of the Mean
PAI pretest for students in Arizona-based course, with matching posttest	27	37.93	8.735	1.681
PAI posttest for students in Arizona-based course, with matching pretest	27	41.44	9.014	1.735
PAI posttest for Arizona State University students in conventional course (no pretest was given)	753	35.27	8.824	0.322

Note. Maximum possible PAI score is 60 and minimum possible score is 12. A PAI score above 36 indicates affirmative place attachment.

TABLE 4
Statistical Analysis of Mean PAI Scores for Students in the Arizona-Based Course

	Paired Samples Test							
	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Standard Deviation	Standard Error of Mean	Lower	Upper	*t*	*df*	*p* (Two-Tailed)
Post-PAI to Pre-PAI	3.519	6.223	1.198	1.057	5.980	2.938	26	.007

Paired Samples Correlation

	n	Correlation	Significance
Post-PAI to Pre-PAI	27	.755	.000

$p < .01$. We are 95% confident that the interval 1.057–5.980 contains the true population mean difference. There was a high correlation of .755, indicating that 58% of the variance in the posttest scores is explained by the pretest scores.

Place Meaning

Results from the PMS paired prepost comparison (Table 5) show a gain in mean PMS score, signifying enhancement of the meanings that Arizona holds for students from immediately before the Arizona-based course to immediately after it.

Using a non-directional-dependent samples *t* test (results in Table 6), we found this gain to be significant, $t(26) = 7.169$, $p < .01$. We are 95% confident that the interval 9.38–16.92 contains the true population mean difference. There was a moderate correlation of .593, indicating that 35% of the variance in the posttest scores is explained by the pretest scores.

TABLE 5
Comparison of Mean PMS Pretest and Posttest Scores for Students in the Arizona-Based Course

	n	Mean Score	Standard Deviation	Standard Error of the Mean
PMS pretest for students with matching posttest	27	101.5	11.27	2.170
PMS posttest for students with matching pretest	27	114.7	9.584	1.844

Note. Maximum possible PMS score is 140 and minimum possible score is 28.

TABLE 6
Statistical Analysis of Mean PMS Scores for Students in the Arizona-Based Course

	Paired Samples Test							
	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Standard Deviation	Standard Error of Mean	Lower	Upper	*t*	*df*	*p* (Two-Tailed)
Post-PMS to Pre-PMS	13.15	9.530	1.834	9.38	16.92	7.169	26	.000

Paired Samples Correlation

	n	Correlation	Significance
Post-PAI to Pre-PAI	27	.593	.001

DISCUSSION AND CONCLUSIONS

Can significant changes in place attachment and place meaning be discerned in student populations such as our experimental group (Research Question 1)?

Our data indicate that statistically significant gains in the two principal components of sense of place, place attachment and place meaning, were measured in a place-based educational context using published psychometric surveys, even though such instruments were developed in other places and for other purposes. Using the methods of empirical construction, authentic synthesis of interpretative and quantitative methodologies, and validation now available (e.g., Vázquez et al. 2006; Williams & Vaske, 2003), it is possible and desirable to create sense-of-place assessments better suited to specific places and curricula. Our research group is currently documenting place meanings in a geologically, culturally, and ethnically diverse region of central Arizona where we are also working with in-service teachers, with the objective of developing a locally emergent place-meaning survey.

Changes in place attachment and place meaning can be included with other cognitive and affective learning outcomes; in the case of place-based teaching and similar situated methods, they should be further explored as authentic assessment measures.

Does place-based teaching enhance students' attachment to places, and enrich the set of meanings these places hold for them (Research Question 2)?

Our results suggest that the Arizona-based course enhanced students' attachment to, and richness of meanings represented by, the conceptualization of Arizona used as the setting for the course. This, considered with the environmental and cultural relevance of the method, would recommend it for use in naturally and culturally diverse regions such as the Southwest United States. However, because of the small sample size in this preliminary test, and as a controlled study was not possible, we cannot rule out other explanations for the observed effect, such as class size, instructor enthusiasm, or extraordinary senses of place among the self-selected student volunteers. The high correlation between our PAI pretest and posttest results is noteworthy, in that students who bring strong prior senses of place into a place-based course may respond better to the method. Various extracurricular influences on place attachment, such as residence, outdoor experience, recreational interests, and income and education levels, are recognized (e.g., Williams et al., 1992). It was not our intent to investigate the effects of any of these factors on student senses of place in this preliminary study, but we examine some in another study (Semken, Butler Freeman, Bueno Watts, Neakrase, Dial, & Baker, 2007).

Place and sense of place are concepts that have been defined and characterized thoroughly enough to be accessible to science educators. Sense of place—meaning and attachment, cognition and affect—is in essence what place-based education is intended to teach. Such methods, which actively engage and enhance the senses of place of students and teachers, are highly appropriate for the earth, ecological, and environmental sciences. The application and innovation of psychometric measures of sense of place, in the authentic assessment of place-based science teaching, merit continued study.

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