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Ethnographic methods in analysis of place-based geoscience curriculum and pedagogy

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ABSTRACT

Place-based education is locally situated, experiential, and transdisciplinary. It is informed not only by scientific knowledge of places and regions, but also by the humanistic meanings and affective attachments (senses of place) that people affix to them. Enhanced sense of place is an authentic learning outcome of place-based teaching. Qualitative analyses of a student's behavior and attitudes in a place-based learning context can be used to triangulate instrument-driven psychometry of pre- to postexperience changes in sense of place and content knowledge. Two qualitative ethnographic methods, direct behavioral observation and semistructured interviews, were used formatively and summatively in a Southwest-based earth science course offered to in-service teachers in two underserved rural Arizona school districts in 2006–2007 and 2007–2008. Direct observations were obtained as field notes and video recordings, which were transcribed and coded in an ethogram to ascertain engagement with curriculum and pedagogy. Ethnographic analysis demonstrated increased engagement with place-based course elements over more globally situated components. For interviews, a questionnaire was developed to elicit cognitive and affective responses regarding the course, its curriculum and pedagogy, and the student's sense of the places studied. Verbal, text, and content analyses were applied to the interview data to uncover concepts, patterns, and relationships that were linked into thematic categories. Positive responses to the place-based approach were reported by a majority of participants in three areas: enhanced place attachment and meaning, enhanced science comprehension, and enhanced teaching. These ethnographic methods offer a means to evaluate situated, transdisciplinary teaching for which quantitative instruments may not capture all relevant outcomes.

INTRODUCTION

Place-based education is philosophically rooted in civics and environmental education. While initially practiced mostly in small, rural precollege settings, place-based teaching is now being applied to a much broader range of educational levels and contexts (Sobel, 2004; Gruenewald and Smith, 2008). Geoscience educators are part of this movement, as demonstrated by

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a fully subscribed, far-ranging, and well-attended topical session on place-based education at the 2009 Geological Society of America Annual Meeting (GSA, 2009).

Place-based education is not simply experiential teaching, or teaching in the field or community, or the use of local examples of features or processes, although these are all important attributes of the approach. Authentically place-based teaching is fully situated in *place*, which is a social construct that has been defined as any locality imbued with meaning through human experience (Tuan, 1977). Place meanings accrue and evolve as various people and cultures occupy or otherwise interact with a place diachronically and for different reasons. Significant features among these meanings are culturally defined landscapes, heritage, and social values. For example: Grand Canyon, one of the most iconic landscapes of North America, is sacred territory to a number of Native American nations. The canyon and its environs are richly endowed with indigenous place names and stories tied to specific landforms, and populated by many places that are either inhabited or ceremonially visited by Native American peoples. This place was at the heart of one of the last and most storied regional traverses by nineteenth-century American explorers and is a landscape that has encoded and now reveals nearly two billion years of geological history. Grand Canyon has been portrayed in endless works of visual and literary art, has been subject to mining activities, was once threatened with submergence for hydroelectric power generation, and is a beloved National Park visited by millions each year.

From this perspective, scientific knowledge obtained in and of a place is seen as one subset of its meanings, on its face not necessarily more important or relevant to learners—particularly those with personal or cultural connections to the place—than any of the other forms of meaning (Semken, 2005). Ideally, place-based teaching is experiential and transdisciplinary, engaging with the full set of meanings known for the place or places under study, and integrating both scientific and humanistic inquiry into these places. This approach is intended to provide more engaging context and scaffolding for diverse learners (e.g., Kawagley and Barnhardt, 1999; Lim and Calabrese Barton, 2006), to teach global concepts through local examples (Gruenewald and Smith, 2008), to promote environmental and cultural sustainability (Orr, 1992; Sobel, 2004), and to evoke care and concern for places. In practice, a spectrum exists that extends from the use of meaningful places simply to illustrate disciplinary concepts, to a complete integration of disciplines with place as the focus (Ault, 2008). If textbooks and published or online curricula are useful indicators, most geoscience teaching is not far along this continuum.

To fully encompass the transdisciplinary qualities of authentically place-based education, defined learning outcomes should include but also transcend disciplinary knowledge and skills, so that the student's personal connection to place can be leveraged, enhanced, and assessed. This connection involves not only cognitive factors but also affective factors, as people tend to form emotional attachments to meaningful places (Shamai, 1991). The *sense of place*, defined as the set of all of the meanings and affective attachments that an individual or a community maintains for a given place (Brandenburg and Carroll, 1995), usefully represents this connection. This construct has a strong theoretical foundation in geography, environmental psychology, and rural sociology (for a review, see Semken and Butler Freeman, 2008).

Validated quantitative instruments have been developed to empirically measure and characterize sense of place in different groups (e.g., Williams and Vaske, 2003). For these reasons, Semken and Butler Freeman (2008) proposed that leverage and enhancement of the senses of place of students and instructors should be considered a valid learning outcome of place-based teaching and assessed in tandem with traditional measures such as content knowledge.

Previous work on sense of place in place-based geoscience education (Semken and Butler Freeman, 2008; Perkins, 2008; Semken et al., 2009) has been mostly quantitative and focused on (1) characterization of sense of place in diverse student and nonstudent groups, and (2) pre- to postassessment of changes in senses of place of students in experimental place-based undergraduate courses. The results of these psychometric studies show that sense of place can be measured and that significant pre- to postexperience gains in student sense of place have been observed in some classes. To date, this work has been limited by small study populations, but it is ongoing.

ETHNOGRAPHIC RESEARCH IN SCIENCE EDUCATION

Place-based education constitutes a significant philosophical shift in content and pedagogy that requires innovative assessment design. It is to be expected that instrument-driven quantitative characterization and assessment of the method, though valuable, will have limits. Qualitative research methods expand the range of assessment tools available to researchers, to include those that capture attitudes and behavior. Qualitative analyses can and are used to triangulate and refine instrument-driven quantitative assessment.

Qualitative methodologies encompass a wide range of methods, including "ethnography," a naturalistic method of inquiry rooted in both empiricism and humanism (Denzin and Lincoln, 2000; Bernard, 2006). Ethnography is the systematic description of a specific culture and is concerned with individual variation within a particular cultural group (Barfield, 1997). Both during the process and in the product of research, ethnography employs various rigorous quantitative and qualitative methods. The ethnographic methods most often employed in field-based research include observations, interviews, surveys, focus groups, field notes, and text analysis. These methods are by no means restricted to the study of cultures (Barfield, 1997; Handwerker, 2001); other fields of social science also use them to characterize and find causes for specific individual and group behaviors and events (Spradley, 1979; Wolcott, 1987; Handwerker, 2001; Bernard, 2006).

Ethnographic methodology in education research is adapted from the anthropological study of human cultures (Schensul et al., 1999) and investigates teaching and learning from the perspectives of the participants themselves (Wolcott, 1987, 1990, 1994; Cohen et al., 2007). It allows for a multilayered approach to assessment and is especially useful for formatively gauging the attitudes, behavior, and self-efficacy of students and teachers participating in a class or other type of educational intervention.

The project described here employs ethnographic techniques (Wolcott, 1987) to evaluate the perceived efficacy of place-based geoscience learning. As such, the focus was on individual and group behavior, knowledge acquired, and affective responses to the course, rather than cultural analysis or ethnography. Hence, it is most accurately described as an ethnographically informed study. Because place-based education is experiential and contextual, ethnographic methods are especially useful to identify and assess these factors and to uncover any interrelationships that may exist among them. This paper details the application of two ethnographic methods, semistructured interviews and direct behavioral observation, in assessing the place-related efficacy of an experimental place-based earth science enhancement course for in-service teachers.

RESEARCH SETTING

The project was centered in Superior, Arizona, ~80 km east of Phoenix: a small, struggling community situated in a geologically, ecologically, and culturally diverse zone where the Basin and Range and Transition Zone physiographic provinces meet. Fault-block mountains loom immediately east of town, and the steep elevational gradient locally compresses the ecological transition from the lower Sonoran Desert to piñon-juniper-oak woodlands and then to ponderosa pine forests (Ffolliott and Gottfried, 2008). Queen Creek, a major tributary of the Gila River system, originates here and descends through a spectacular canyon to the desert floor at Superior. The mountains consist of Proterozoic to Mesozoic sedimentary and igneous rocks that were extensively mineralized with copper and silver in the mid-Cenozoic (Hammer and Peterson, 1968; Manske and Paul, 2002). The region around Superior was originally part of the ancestral homelands of the Yavapai and Apache peoples, who maintain ties to the area, and is rich in archaeological and cultural sites. Mining began in the 1870s and attracted Mexican miners, whose descendants today comprise most of Superior's population, as well as smaller groups of Eastern Europeans and Chinese.

Like most extant mining towns, Superior has withstood several cycles of boom and bust, but it is currently in a period of severe socioeconomic downturn and population loss initiated by the closing of the last major copper mine in the 1990s. A new, technologically advanced mine has been proposed to tap another copper deposit east of town that is extraordinarily rich but dauntingly deep. The plan and prefeasibility studies for the new mine have stimulated some new economic growth, and both optimism and controversy (Semken and Brandt, 2010).

About half of the participating teachers traveled to Superior each week from the San Carlos Apache reservation located ~60 km to the east. The San Carlos Apache Nation is wholly rural, largely agrarian, and one of the most economically impoverished Native American communities in the United States. As noted previously, most San Carlos Apaches consider the Superior area to be part of their homeland, and many Apache families conduct ceremonial and recreational activities in the highlands east of the town.

STUDY PARTICIPANTS

Place-based science teaching has been identified as the most appropriate and inclusive pedagogy for students who have strong multigenerational cultural ties to their home landscapes (Kawagley and Barnhardt, 1999; Cajete, 2000; Riggs, 2005), such as Native Americans and Mexican Americans in the southwestern United States. These students have historically been underrepresented in geoscience studies and careers (Huntoon and Lane, 2007; Riggs et al., 2007). To investigate the potential and efficacy of this approach, a graduate-level Arizona- and Southwest-based earth science enhancement course was offered to practicing (in-service) teachers from two underserved minority-majority school districts in rural south-central Arizona.

The course was entitled *Situating Earth Science in Superior* (SESS). It was taught by the second author, an ethnogeologist and geoscience education researcher. The first author, an anthropologist, recorded behavior and conducted interviews. The authors were thus situated in the study as researcher-participants.

Study participants were in-service teachers grouped in two cohorts by academic year: 2006–2007 (cohort 1, abbreviated C1) and 2007–2008 (cohort 2, abbreviated C2). Each of the two sessions of SESS took place from late autumn to early spring, when the weather was coolest and most conducive to field trips in the desert. An important characteristic of the SESS experiment, reflective of the nature of place-based education, was that teachers from any grade level and any discipline were welcomed to participate and receive academic credit. The only prerequisites were an interest in learning about the Southwest and intent to apply what they would learn in SESS to their own teaching.

A multicultural mix of study participants (teachers) was present in both courses, which reflected the demographics of the study area. Class sizes were comparable for both cohorts: Cohort C1 had 16 participants and C2 had 15. The 15 teachers in C2 included six who completed SESS in good standing the previous year as members of C1, but returned to retake the course because they had greatly enjoyed and benefited from it. Participants self-reported their race or ethnicity as follows: five (20%) Hispanic/Latino, two (8%) American Indian, two (8%) Asian, and sixteen (64%) White, non-Hispanic. All of the participants were employed either by the Superior school district or the San Carlos school district. The majority of participants were native to the area or long-term residents, but six teachers in C1 and five in C2 had recently been brought in under 2-year contracts from the

Midwestern United States to fill teaching vacancies. All of these individuals were new to the Southwest as of 2006.

COURSE AND CURRICULUM

The SESS course models place-based, inquiry-driven practice while introducing (or reintroducing) area teachers to the surrounding physiography, rocks, structure, geologic history, hydrology, and mineral resources of their surroundings, in the context of their cultural and historical meanings.

SESS is an abridged but more hands-on and experiential version of an Arizona- and Southwest-based introductory geoscience course that was previously developed by the second author for the large-lecture format at Arizona State University. The curriculum for the latter course was described in detail by Semken and Butler Freeman (2008); most of its attributes also apply to SESS and are not elaborated upon here. Geoscientific content is organized under the theme of interacting rock, water, air, and life systems: a concept that bridges mainstream earth system science and indigenous Southwestern ethnoscience (Cajete, 2000; Semken, 2005; Semken and Butler Freeman, 2008).

A "sense of the Southwest" is leveraged and enhanced by frequent evocation (often with imagery, art, quotations, and literary excerpts) of the region's beauty; importance as a home to diverse cultures over millennia; and enduring allure to scientists, artists, and visitors. Some SESS lessons are focused on analytical "case briefs" on regionally situated economic and environmental topics: water and energy resources; copper mining; climate change and drought; and land subsidence and surface fissuring in developed areas. The curriculum also included three optional half-day field trips on Saturdays to nearby outcrops and small mines, to interpret the geological histories of and collect samples from exposed strata. The required texts included an inquiry-based introductory geology textbook (Reynolds et al., 2008), a trade book on Southwestern natural history (Wiewandt and Wilks, 2004), and the geologic highway map of Arizona (Kamilli and Richard, 1998).

In both offerings of the course, 10 three-hour interactive lectures were held over 10 weeks, in addition to the three supplementary field trips. In each session, about 2 hours were devoted to lecture, interspersed with 15- to 20-minute sessions of participant activity (e.g., investigation of local rock specimens, interpretation of maps). The course materials were essentially the same for each cohort, but certain activities (primarily field trips) followed slightly different schedules owing to the availability of the participants and instructor or the vagaries of the weather.

RESEARCH DESIGN

The research design was structured to emphasize ethnographic methodologies. Two ethnographic methods, behavioral observation and semistructured interviews, were used in this study. Behavioral observation is a mixed methodology: both scientific and humanistic (Bernard, 2006). This type of observation uncovers the actual behavioral response in a particular situation or event, yet requires interpretive coding of the data collected. Semistructured interviews feature a written set of closed and open-ended questions that shape the discussion but do not constrain the participant's response. This allows for in-depth discussion of the material presented, methodologies used, and the participant's response to it, as well as opening up new avenues of study.

Behavioral Observation

Funding and logistical constraints limited behavioral observation to the first year (C1) only. This method was utilized to ascertain engagement with curriculum elements and place-based method. The observation took two forms: participant observation during each class session, and direct behavioral observation via time-sampling (scans) of video recordings of each class. The study participants (teachers) were fully informed of the recording prior to the study, and all signed informed consent forms, though one individual did not wish to be visible on any videotapes. This was accommodated through the positioning of the camera, which placed that participant in acoustic but not visual range.

Behavior was recorded in situ via participant observation using field notes. This type of ethnographic method, focused on participant activity, can be sensitive to an individual's place meaning and place attachment because behavior is often place-specific (Bernard, 2006). Field notes detailed the behaviors of individuals and groups, and provided analytic descriptions of the research setting, structural elements, curriculum, activities, and characteristics of individuals and their behaviors. Field notes enabled the researcher to document the context of behavior and to describe the patterns and interrelationships among individuals, phenomena, and behavior. For example, it was noted that during class particular students sat up, leaned forward, and began asking questions of the instructor when geological processes were illustrated by reference to specific local places. This behavior would pull other, less engaged students into the discussion. Another student exhibited discomfort, via bodily movements and facial expressions, whenever geologic time was discussed.

This type of observation allows the researchers to assess interactions within the particular setting as well as with the material presented far more accurately than self-reported behavior (Bernard, 2006). This method is limited, however, by the constraints of the researcher's ability to observe and record multiple participants and hidden multiple meanings within behavior, to which the researcher may not have access. Hence, interviews were conducted, and video recordings of each class were also made in order to offset the limitations of the field notes.

Direct behavioral observation of individuals in a research setting is often done by means of an ethogram. Ethograms are a form of continuous monitoring that have been most often associated with primate studies, and used to catalogue specific, discrete behaviors (usually innate; Bernard, 2006). However, they

have been increasingly used with humans, to record behavioral patterns and facial expressions, in such fields as behavioral psychology, anthropology, and architecture (Kneidinger et al., 2001; Bernard, 2006). An ethogram is a list of specific behaviors that are recorded focally (on a single individual) or as scans (on multiple individuals) to elicit the range, frequency, and description of behaviors. In this case, behaviors were identified through the preliminary scanning of multiple videotapes and field notes. An ethogram (Fig. 1 is a sample excerpt) was developed from preliminary scanning of the videotapes, full transcripts of the recordings, and comparative analysis of field notes. This list of behaviors was then evaluated and translated into a set of specific, easily observed behaviors to be monitored and recorded for each taped session. This permits quantitative and qualitative coding and assessment of observable behavior patterns, which may be difficult to assess otherwise (Bernard, 2006).

		Time (min)		
	Value	**4**	**8**	**12**
Body position				
Leaned forward	+	0	4	6
Relaxed	~	11	7	4
Slumped	–	0	0	0
Turned forward	+	10	11	11
Turned away	–	1	0	0
Seated	~	11	11	10
Standing	~	0	0	1
Walking	~	0	0	0
Gaze				
Forward	+	7	10	5
Away/D/ On-topic	+	2	1	6
Away/D/ Off-topic	–	2	0	0
Away/ND	–	0	0	0
		Time (min)		
	Value	**0**	**4**	**7**
Verbalization				
Teacher-D	+	0	3	4
Other-D/ On-topic	+	0	1	3
Other-D/ Off-topic	-	0	0	
Localized	+		4	7
Global	~			
Content	+			
Method	+			
Off-topic	–			
Writing				
	+	2	1	0
Use of materials				
Hand lens				X
Rocks				X
Handouts				
Movie				
Lesson content				
Global		X		
Regional				
Local			X	X

Positive behaviors (indicated by **+** in **Value** column):

Posture:	Body turned toward teacher, screen
	Body leaning forward
Gaze:	Turned directed (D) forward toward teacher, screen
	Turned away but on-topic (handouts, rocks, etc.)
Verbalization:	Directed toward teacher/on-topic
	Other directed/on-topic (classmates)

Negative behaviors (indicated by **–** in **Value** column):

Posture:	Body turned away from teacher, screen
	Body in a slumped position
Gaze:	Directed away/off-topic (other objects/persons)
	Nondirected (ND) gaze (wandering/glazed)
Verbalization:	Directed to others/off-topic
	Teacher directed/off-topic

Neutral behaviors (indicated by **~** in **Value** column):

Posture:	Relaxed
	Standing, walking (dependent upon activity in room)
Gaze:	None identified
Verbalization:	Responses to direct questions without a switch in topic

Figure 1. A sample ethogram for engaged classroom behavior, showing classification and tally of behaviors made from observation of a video recording.

Interviews and Questionnaire

Semistructured exit interviews were conducted with each class participant in both C1 and C2, following the completion of SESS, with the exception of one participant in C1 who moved out of state before he could be contacted. Interviews were held as closely as possible to the final class session in May, and most were completed within 2 weeks of that time.

The questionnaire (Table 1) was designed to elicit both affective and cognitive responses regarding the class itself and the participants' sense of place. Fifteen questions were asked of each participant, half of which were open-ended. Affective items were grouped into evaluations of the class and responses regarding the area around Superior and San Carlos (place) and the greater Southwest region. Cognitive items were centered on pedagogy and the place-based approach. These included: (1) assessments of the class content, focus, and structure, (2) strengths and weaknesses of the course, and (3) the participant's own plans for implementation of place-based teaching. The first three questions elicited residence and career patterns, including length of residence, family residence history, and the participant's career plans. These data were used to establish a baseline residence pattern. Activity patterns and affective responses to place and residence were elicited in four additional open-ended queries. Three additional open-ended questions were designed to elicit place attachment and meaning both locally and regionally. The remainder of the queries addressed course strengths and weaknesses, and the respondent's general feelings about the course.

DATA COLLECTION AND ANALYSIS

Direct Behavioral Observation

The number of participants made it impossible to record behaviors continuously for each participant. Time-sampling (also called instantaneous spot sampling) allowed for accurate recording at specific intervals to ensure a representative sample of behavior. Each scan lasted 1 in, in which the behaviors of each visible participant were recorded, and was repeated at 4 min intervals throughout the session. The content of the lecture material, or discussion, was also recorded at each interval as either global or place-based. Videotaped behavior was coded twice: initially in the summer after the course, and then after a period of 3 months using the same parameters that were established prior to coding. The coded behaviors were then enumerated, and frequency counts were tabulated. The layout of the classroom was such that only about two-thirds of the participants could be video recorded at any one time. Since the participants generally placed themselves in the same location each class, the subjects were held constant. Scans were recorded manually and included lecture and demonstrations but not student activities. This was in part due to the difficulty of accurate assessment. Participants in these activities were coalesced into dense group settings and too far away for accurate audio and video recording. In addition, the experiential nature of the activities created a contextual setting that could be confused with place-based emphasis and thus muddy results.

TABLE 1. QUESTIONNAIRE USED FOR EXIT INTERVIEWS

1.	How long have you lived in the Superior/San Carlos area?
2.	Do you have family living in the area? If so, who are they and how long have they been here?
3.	Do you plan to continue teaching here for at least five more years? If not, where do you plan to go?
4.	What do you think about the Southwest-based focus of the course?
5.	How did what you learned in this course affect how you think and feel about the Southwest?
6.	In what ways will what you have learned in this course impact your teaching in the future?
7.	What two things about this course were the most useful or most successful, in your opinion?
8.	Which two things about or in this course most need to be improved, and how would you recommend doing this?
9.	How much time do you spend in the Superior area?
10.	If you had a choice, would you continue living in this area?
11.	If you plan to leave the area, would you return? Why or why not?
12.	What types of activities do you participate in that are specific to this area?
13.	Describe your feelings about this area? The Southwest in general?
14.	How would you characterize your relationship, or how would you describe your feelings about the Superior area? With the Southwest?
15.	What is or are the most important feature(s) or characteristic(s) of this area for you? That you think students should learn?
16.	How has your view of the Southwest changed as a result of taking the course last year? Please be specific.*
17.	How have you implemented what you learned or practiced in the course last year in your own teaching? Please be specific.*

*Items 16 and 17 were administered only to cohort C1 teachers who returned in C2.

Observed behaviors were categorized and coded as either states or events. States are ongoing time-dependent behaviors, while events are punctuated or short-term behaviors that intervene within a state. Three general groups of behavior were documented: body position, gaze, and verbalizations. These were further broken down into discrete, easily identifiable units in order to log them accurately. For example, body position states were classified as seated, standing, or walking. Body position events were identified as turned forward, turned away, leaning forward, relaxed, or slumped. Gaze was treated as an event (because of its punctuated nature) and was categorized by focus and position. Four types of gaze were identified: forward, away but directed on-topic, away and directed off-topic, and away but non-directed. Verbalizations were initially categorized as teacher-directed, other-directed but on-topic, and other-directed but off-topic. In addition, the content of verbalizations was coded as being local (place-based), global, or off-topic. This allowed the researcher to distinguish interest in the material presented by the instructor from interest directed elsewhere (toward other participants, personal materials, or unfocused and unengaged). Behaviors were then classified as positive, negative, and neutral. Positive behaviors were those that exhibited a direct connection to the instructor or material presented (e.g., leaning forward, speaking to the instructor or a participant about the material presented, a change in gaze-focus to the instructor, etc.). Negative behaviors were those which indicated that the participant's focus was directed at something or someone other than the instructor or the material being presented (e.g., turned away, talking on a cell phone, gazing into space). Neutral behaviors were those behaviors expected in a class setting or those that were ambiguous (e.g., sitting in a chair and turned forward, relaxed posture, changing gaze). The results of the observational studies were then compared to field notes taken in situ.

Verbalizations in the Classroom Setting

In the context of the recording of behaviors, it became apparent that student verbalization offered some tantalizing clues to engagement, interest, and efficacy. It was therefore decided to re-code the raw data and analyze both student and instructor verbalizations within the classroom setting, via continuous monitoring (rather than in 4 min intervals), in an attempt to elicit new information. This enabled the researchers to obtain both quantitative and qualitative data and allowed for more nuanced analysis. Participants were divided into two categories: instructor and students. Verbal episodes, defined as vocalization by a participant with a clearly understood meaning, were identified as the primary units of analysis. A verbal episode could manifest as either a single vocalization or a verbal interaction occurring between the instructor and a student or students.

Coding categories were developed inductively from participant observation, field notes, and interviews, and then applied systematically (LeCompte and Preissle, 1993). A subset in the behavior pattern of verbal episodes was revealed that appeared to indicate increased interest: uninitiated student responses. Student categories were thus made more specific to capture both initiated and uninitiated verbal episodes. Each verbal episode was therefore further categorized as being either instructor-initiated (IL—instructor lecture; IRP—instructor response; or IQ—instructor question) or student-initiated (SRP—student response or SQ—student question). This allowed for the identification of 10 interactive forms, depending upon which participant initiated the exchange, as well as the presence of uninitiated responses: (1) IL-SRP, (2)IL-SQ, (3) IRP-SQ, (4) IRP-SRP, (5) IQ-SRP, (6) IQ-SQ, (7) SRP-IRP, (8) SRP-IQ, (9) SQ-IRP, and (10) SQ-IQ. Instructor lecturing was held to be the baseline behavior, which removed verbal exchanges that resulted in the resumption of the lecture from consideration.

Each verbal episode, whether a single or interactive vocalization, was subsequently coded as being either global (e.g., related to worldwide plate tectonic processes) or local (place-based; e.g., related to a tectonic episode in Arizona) in content. Uninitiated student responses were then identified and tabulated to determine the global or place-based content of these verbal episodes. Frequency counts were then tabulated for all verbal episodes (as student responses and uninitiated responses), and relative frequency was calculated for each of the categories for each class session. This allowed for episodic differences in general student responses by date. Student responses and questions were then matched against instructor content to ascertain any "switches" in content, global to local or local to global (switch in focus). The actual verbalizations within the domains of "local" (place-based) and "global" (Table 2) were then analyzed via text analysis and coded. These descriptive data yielded characteristics, patterns, and properties contained within the domains, helped to refine our hypotheses, and stimulated new questions.

Questionnaire and Interviews

A multilayered qualitative approach was applied to the formation of the interview schedule and the analysis of the resulting data, encompassing verbal analysis, text analysis, and content analysis. Verbal analysis as outlined by Chi (1997) allows concepts and relationships to emerge from the texts in a form that can be easily quantified. Patterns can be elicited, and these can be grouped into thematic units that allow for further investigation (Chi, 1997). Text analysis is hermeneutic in nature; it focuses on the meanings within texts and their interconnections (Bernard, 2006).

Content analysis is a deductive coding method often concerned with determining form, substance, or trends (Berelson, 1971; Titscher et al., 2000; Bernard, 2006). This research strategy can be combined with other techniques to interpret data from any form of text (written, verbal, or nonverbal). It proceeds from the assumptions that valid inferences can be made between intent and content and content and effect, and that this study is meaningful (Berelson, 1971). Analysis may take several paths depending on the approach utilized. The research questions themselves dictated

TABLE 2. CATEGORIZATION OF PARTICIPANT VERBALIZATIONS

	Participant responses			Participant switches in focus			Uninitiated responses		
Lesson dates	Global	Local	Total	Local to global	Global to local	Total	Global	Local	Total
4 December 2006	57	29	87	0	0	0	5	7	12
11 December 2006	109	191	300	0	0	0	4	5	9
18 December 2006	56	17	73	2	2	4	7	7	14
8 January 2007	15	6	21	1	1	2	5	3	8
29 January 2007	54	32	86	0	1	1	7	10	17
5 February 2007	44	17	61	2	4	6	8	11	19
26 February 2007	69	16	85	0	1	1	6	5	11
5 March 2007	43	40	83	2	2	4	8	16	24
Totals	447	348	796	7	19	26	50	64	114
Percentages	56	44	100	27	73	100	44	56	100

whether a more quantitative or qualitative approach was used and hence the forms of data analysis that best fit the research.

Interviews were transcribed, and an initial reading was done to ascertain categories of interest and units of analysis. All interviews were completely coded and included in the analysis. Initial coding of analytic units was done by two research assistants (a science-education graduate student and a psychology undergraduate student), using coding categories agreed upon among the research assistants and the first author. Analytic units were of two types: recording and contextual (Titscher et al., 2000). Recording units are small textual units that indicate definite categories or meanings and hence are usually one-word or a phrase in length (e.g., "yes," "It hasn't changed," "beautiful"). *Contextual units* are multisentence and thematic (e.g., "360 degree panoramas that take your breath away," "brings up the story of our culture"); these explain and elaborate on the initial response. Patterns in the results were noted, and contextual coding and analysis were captured by the first author. These were dependent upon the source material and research questions.

The cognitive and closed (fixed-choice) question section of the questionnaire was designed to facilitate coding by dyadic or occasionally triadic responses. These responses took the form of yes/no, more or less than five years residence, will affect/won't affect, and so on, and were determined to be recording units. This facilitated coding of the responses because categories were easily identified and were explicit. Thus, in this section, category formation preceded analysis (Sepstrup, 1981; Titscher et al., 2000). These questions also allowed for elaboration upon the initial response, however, as each response also included a phrase, sentence, or paragraph in the participant's own words. This created larger contextual units of analysis. Category formation in this type of textual unit proceeds from the text itself and is implicit (Berelson, 1971; Titscher et al., 2000; Bernard, 2006). Open-ended and affective questions were broken down into categories as the texts presented them. These generally fell within three to four themes per question. Responses were then coded into these categories using phrases or sentences that clearly elicited the meaning as conveyed by the participant. Patterns were detected in this initial coding and subsequently quantified. The responses were then qualitatively reevaluated and coded according to the patterns and themes detected. This allowed for re-categorization into more specific and meaningful categories and also into general thematic units, which were then quantified to ascertain the results presented here.

For example, when participants were queried as to the possible impact the place-based SESS course might have on their own teaching, initial coding identified two categories: *will affect* or *won't affect* (recording unit). The elaborated responses (contextual units), however, revealed additional patterns within this dyad. Participants identified changes in the focus of their teaching, the methodology they planned to utilize, or the content of their instruction. These categories could have been grouped under the overarching theme of enhanced teaching, and quantified. However, the coded categories exhibited a richer meaning.

Participants were also asked to describe how the course affected their feelings for the Superior–San Carlos area (question 5), and, later, in a separate question (13), what their feelings for the area in general were. The first question was initially coded according to the themes that emerged from the responses. These were a greater understanding of the geology of the area, an appreciation for the area, a desire for more information, and no change. The second question was coded initially for emotional, descriptive, or not applicable responses. Affective responses might include "I feel connected to this place" or "It's kind of depressing..." Descriptive items included, "It has its own beauty," or "It's beautiful." Themes were identified within these responses and in the responses as a whole. The open-ended nature of question 13 allowed for determination of baseline affective meanings, which were then cross-checked with the responses to question 5. These two questions were then re-coded. Other items in the questionnaire also elicited responses that fell into these categories. The structure of the questions allowed participants to explain

how and why they answered as they did. For example, question 15, concerning the most important feature or characteristic of the area, elicited a response of "Superstition Mountains! I have loved the Superstition Mountains since my parents first came here. And I call it my mountain."

RESULTS

Interviews

The results obtained from the interview portion of the research were grouped into three thematic categories: enhanced place attachment and meaning, enhanced science comprehension, and enhanced teaching. Response totals for each category are presented in Table 3.

Of the 15 participants in C1, 53% reported a positive affective result in place attachment or place meaning. A positive result was reported by 87% of the participants in C2. Deconstructing the larger contextual responses and then recoding them enabled the researchers to identify larger thematic domains underlying the responses. These included an increase in appreciation, connection, and sense of place, as well as an increase in understanding of and a more personal relationship with place. One participant noted "...you look at these mountains, you see them but, you don't know anything about them...It makes me appreciate them more." Inquiries into place-specific activities revealed an engagement with place, specifically mountains ("This gave me an adventurous trend of exploring the area"), but also activities that plumbed the rich historical and cultural senses of the area: "...our history is here" and "it's our culture and all our traditions connecting us." A participant who took the class twice put it most evocatively, "Last year it was like I was awakened from a sleep. Not being familiar with what was out here...When I took [the second author's] class I was just like 'Wow!'...I look at the area differently now. I knew the names of the rocks." Another noted, "It's a whole different new world that's opened up."

Cognitive results were itemized by science content and focus (as exemplified by the thematic, inquiry-based curriculum). Participants in both cohorts reported a significant increase in place-related scientific knowledge. Many participants specifically noted

TABLE 3. RESULTS OBTAINED FROM SEMISTRUCTURED INTERVIEWS

	Cohort 1 (N = 15)	Cohort 2 (N = 15)
Enhanced place attachment and meaning	8	13
Increased appreciation	7	10
Increased connection	3	7
Increased understanding	5	6
Deeper sense of place	1	1
Personal relationship	6	7
Enhanced science comprehension	10	6
Focus (inquiry, scenario-based)	2	1
Content (depth, breadth of knowledge)	9	5
Enhanced teaching	10	13
Focus (professionalism, place)	2	8
Method	5	3
Content	8	9
Implementation		
Concurrent	11	13
Intended	11	8
Actual	3	5
Subsequent		6
Actual	N.A.*	4

*N.A.—not applicable.

the volcanic activity in the area, and regional rock-forming and geomorphic processes, as valued knowledge gains. C1 documented a 67% increase while 40% of C2 participants reported increased science comprehension. This was overwhelmingly based on content rather than focus. As one participant put it, "...you're kind of tunnel-vision and now I look at how the layers are there and these cuts in the roads or a peak sticking up—looking at how it's starting to disintegrate and break down and how the canyons come together." However, for some, it was the place-specific inquiry process that they felt led them to a better understanding of the material.

Enhanced teaching was very positively reported: 67% of C1 participants and 87% of C2 participants noted gains in focus, methodology, or content. Content and focus were responsible for over half of the gains, while gains in methodology were noted by less than one-fourth of the participants. Teacher-participant comments on implementing place-based content and pedagogy within their own classroom were also elicited. These were categorized as concurrent implementation, for those teachers who implemented content or pedagogy in the same year they took SESS, and subsequent implementation, to capture comments from C1 teachers who returned in C2. These two categories were each further subdivided into intended implementation and actual implementation. Eighty-seven percent of all participants stated that they would implement either knowledge gained or procedures learned within the course. Participants spoke about the need for students to understand what rocks, landforms, and resources were present in the area, and how these developed: "They need to be aware of the aquifers and how the Southwest developed, where they are at.... They are not really aware. They just take what they see for granted."

However, only 20% of C1 participants and 33% of C2 participants reported actual implementation at the time of their interviews. These were most often those participants who taught some form of science. One science teacher reported "I just did my project on a whole earth science unit. Everything I learned was applied into what my project is going to do." Another participant who taught both geoscience and social studies implemented a lesson on plate tectonics and volcanoes in the Southwest. However, of the six C1 participants who returned in C2, four had implemented and planned to continue implementing place-based content. Half of these were not science teachers. For example, one participant who taught English at San Carlos incorporated specific content and a change in focus in her composition classes: "I had the students write about peridot in their compositions or about Point of Pines, where they like to go fishing, camping, hunting, or all that. What they write is just beautiful. I also shared Apache Leap [a culturally significant tuff ridge that looms over Superior] with the students. Lots of them weren't aware of what happened there." Another English teacher not only assigned place-specific books to be read but often brought in locally collected specimens (rocks, plants, found objects) and had the students write about these. Those who indicated that they did not implement content or pedagogy were not teaching in the classroom at the time of the interviews.

Direct Behavioral Observation

Direct behavioral observation supported the results found in the interviews. Field notes and the ethogram showed that behaviors indicative of increased interest or engagement with the material presented were documented in every class session. Differences were noted in the behavioral characteristics of the participants when they were presented with place-based content versus global content. These differences consisted of changes in body posture to a forward-leaning position, movement of the visual gaze to one which was oriented directly at the instructor, and teacher-directed verbalizations that centered upon place-based content. Coding gaze and verbalization into discrete directed behavior (i.e., teacher-directed or other-directed, but on-topic) captured a broader range of engagement. Participants might not be focused upon the teacher when specific place-based material was discussed but instead might be commenting about the example to a fellow student or looking at rock specimens. In fact, participant-participant (other-directed) comments were most frequent during place-based discussion, and these were consistently on-topic, often with some personal connection to the place mentioned. While positive behaviors were always greater during place-based material, the class periods that were predominantly place-based showed large gains in both the intensity and vibrancy of verbalizations and gaze, as well as in sheer numbers of all positive behaviors across the board. While enumerating and analyzing the behaviors yielded important data on engagement and interest, it was the qualitative analysis of the behaviors that provided even more understanding of place-based engagement. Individual participants might lean forward casually or with great vigor. Participant comments might demonstrate a process of integrating the material with the place-based example or might instead offer cultural insights and personal connections to the given place. While the sample size was too small to allow for statistical significance, these observations coupled with interview analyses provide impetus for further ethnographic and mixed-methods study of place-based or similarly situated (e.g., problem-based) teaching and learning.

Verbalizations

Qualitative (text and content) analysis of the verbalizations demonstrated intriguing results. Student responses appeared dependent to some degree on the material presented; global content generally elicited student responses that were also global in content and vice versa. However, student responses demonstrated switches in content. These switches were overwhelmingly global to local (place-based) in focus: ~73% of the time (Table 3). An example of this type of shift or switch occurred during a lecture centered upon crystallization processes. A participant interrupted to ask if the stalactites and stalagmites in Carlsbad Caverns (in southeast New Mexico) were formed by these same processes. In another episode, several participants responded to discussions

of volcanism with queries and anecdotes concerning the nearby Superstition Mountains caldera complex.

The majority of uninitiated responses, which suggest a strong participant engagement, were also found to be place-based in character. These responses varied in nature, exhibiting connections from global processes to specific place-based examples (e.g., is there any evidence of glaciation in the desert landscapes in Arizona?), querying information concerning specific places (e.g., was Picket Post Mountain—an igneous butte that looms directly west of Superior—made of lava or ash?), or revealing personal experiences with places. Personal experiences often referred to visits or activities within a particular place, but occasionally revealed specific cultural knowledge. During an inquiry exercise to explore how impact craters form, a Native American participant linked the crater and impact processes under discussion to traditional knowledge. This participant revealed that traditional narratives held that a particular crater (which was not identified or located) was an emergence site from a previous world for her people, and wondered if this idea could be listed as a hypothesis to be tested. Thus, while the absolute number of responses may have remained global in character for a particular class episode, teacher-participants regularly volunteered responses that shifted the focus to place-based content.

Validity and Reliability

Variation exists on the cognitive, emotional, and behavioral scales of study participants, even those who appear to be members of the same culture (Spradley, 1979; Wolcott, 1994; Handwerker, 2001). This is magnified with diverse cultural populations. A dialectical approach, using multiple methods to document results, tacking back and forth between methods, and triangulating results, helps the researchers ensure validity and reliability.

The study population was known in advance to be a multicultural group of participants. The researchers attempted to minimize selection bias by including all the participants in the participant observation and interview portions of the study. The interviews were constructed to help identify cultural differences so these could be taken into account. Structured questions enabled collection of data that historically and culturally situated the participants, whereas open-ended questions allowed for characterization of individual life experiences that may have affected behavior and attitude. All interviews were conducted within the same time frame and in the same general physical setting (the school at which the participant taught), except for one participant. Content and verbal analyses of these interviews provided statistical measures that allowed for comparisons between individuals while text analysis allowed for an in-depth interpretation of participant meanings. Multiresearcher coding, agreement upon categories, and re-coding of contextual variables all enhanced reliability in the analysis of interview data.

Some selection bias in field studies is natural (and sometimes desired; Bernard, 2006) since movement catches the eye more than stationary behavior, louder verbal statements are more readily heard than whispers, and so on. This is the reason why field notes were supplemented with direct behavioral observation in this study. This procedure had several advantages. While field notes were recorded initially at the time of the behavior, observational studies were done approximately 4 months later. This allowed for the synthesis of initial findings and a review of conceptual categories and coding. Observational markers (distinct behaviors) were identified and tested separately. These were then applied universally to all taped participants. Coding and re-coding of raw data after a time lag helped establish reliability in the coding of behaviors, and subsequent refined coding allowed for a more nuanced analysis. While the physical setting for data collection constrained the viewing to only two-thirds of the participants at any given time, the recording camera was placed to maximize the number and diversity of participants (and hence, the data). This created a consistent set of participants for observation and incidentally excluded those participants whose attendance was less consistent.

While field notes identify behavior, subtle interactions, and meanings within the context in which they occur, evaluating behavior with an ethogram focuses attention on discrete segments of behavior isolated from the larger context. Parsing participant behavior into discrete, identifiable actions minimizes researcher subjectivity (Bernard, 2006). These actions could then be re-contextualized after curriculum materials and verbal content were identified and recorded for reference.

Observation does need to account for the random fluctuations and individual variation that occur in the naturally occurring rhythm of time and personal lives. On any given day, participants may have been fatigued, ill, or distracted by personal issues. These factors, as well as personality differences, would affect engagement with any material. However, an attempt to minimize this was made by coding multiple participants and coding each class session, creating continuity. At the same time, behavior without context, focus, and interpretation tells us little. Field notes permitted interpretation of behaviors and understanding of participant opinions, personalities, and histories. As familiarity increased, personality traits became more evident, and this enabled the researchers to distinguish between a reserved but attentive participant and one who was more outwardly enthusiastic.

DISCUSSION

Findings

Ethnographic analyses applied in this study show that in-service teacher-participants in a Southwest place-based earth science course were actively engaged in the material presented. This was documented by behavioral observation and by text and content analysis of verbal episodes. Moreover, participants made repeated connections between the material presented and specific places and experiences within those places. This was demonstrated by switches in verbal episode content from global to local (or place-based), and increased verbalizations and engagement

seen in behavioral analyses. The interviews supported these findings. Participants self-reported gains in engagement, citing cultural ties, emotional bonds, the scenic beauty, and the physical familiarity with specific places as factors. Cultural ties included family residence, ancestral heritage, and community involvement. Responses in these cases took the form of: "My mom and dad live here," "...it's the culture and our traditions connecting us...the sunrise dances," "...there are places I've experienced...," or "As you grow older you tend to realize that this is where you belong." Emotional bonds were frequently noted by references to home and connections; for example: "Superior is my home! I've only been here a little while but this is my home," and "...what I want out of life is here."

Appreciation of the aesthetic beauty of the study region was often focused on mountains and sunsets, described using such phrases as: "It's exotic and unique," "The beauty of the place. It focuses and catches your attention." Physical familiarity also played a part in engagement. Participants could readily examine and identify examples of geological processes. This made it easier to understand the material but also heightened self-reported engagement; e.g., "If you've been here all your life, you pretty much know the area," "...now I look at it in terms of its geological form," "The idea of being able to introduce some of these kids, because they're Reservation kids, to a part of their home that they're not even aware of." These same interviews added depth to observed behavior. One participant who frequently appeared uncomfortable or unengaged stated, "Actually, it didn't change how I felt about the area much...Home is where the heart is, and my heart is not here." Another participant mentioned, "I don't really care about this area that much. It's pretty, but just a place to visit."

In addition, most participants self-reported gains in knowledge. The exit interviews showed these gains to be perceived as gains in the depth of content knowledge ("I can go deeper with my students"), in better appreciation of the surroundings ("I have more appreciation of the landscape...that's an enriching thing"), the acquisition of new skills and methods ("...actually working with a geologic map," "...for me that's a better way to learn, is scenario-based"), a greater sense of place ("I do have more of a sense of place..."), a change in perception or organization ("Using the [place-specific] information to organize your perception, so that it's richer..."), and in cultural grounding ("How different people think...even though it's the same place," "And the addition of the cultural [content]...").

Recommendations and Future Work

A growing body of literature documents the need to reposition and reinvigorate mainstream science teaching to better engage students and teachers through meaning, relevance, and participation (e.g., Barab and Roth, 2006; Tytler, 2007; McWilliam et al., 2008). The highly and locally contextualized and transdisciplinary nature of place-based education is well suited to this use (Ault, 2008; Gruenewald and Smith, 2008). However, authentic and comprehensive learning outcomes for place-based education are complex, overlapping the cognitive and affective domains, and possibly the psychomotor domain as well (Semken and Butler Freeman, 2008). This is a cultural shift in metacognitive teaching that necessitates a culturally informed approach to assessment.

As discussed previously, pre- to postexperience changes in sense of place, attitude, self-efficacy, and content knowledge can be measured, and recent results (admittedly still limited by small sample sizes) favor the continued use of such quantitative tools for assessment (Semken and Butler Freeman, 2007, 2008; Semken et al., 2009). However, these findings do not show how participants engaged formatively with curriculum and pedagogy, nor elucidate their interest in and satisfaction with the approach. These types of data are best ascertained through qualitative ethnographic methods such as the two demonstrated in this study. These methods provide a window into the mix of factors that underlies student behavior, and enables triangulation of quantitative results such as pre- to postexperience gains.

Ethnographic methods and analyses offer many advantages to geoscience education (both in assessment and in learning research), particularly in highly situated or transdisciplinary contexts in which quantitative tools are not sufficient to capture the full range of authentic learning outcomes. Their design is holistic and focused on relationships and patterns within the structure and distribution of events over time, and on an understanding of the social setting in which behavior occurs (Denzin and Lincoln, 2000). Geoscience educators can use these methods to pinpoint realms of tension as well as effective concurrence.

The results of this study also posed new questions for further consideration: Is place-based teaching effective for topics and subjects less locally or regionally situated than geoscience? Does it have lasting impact on K–12 curricula and teacher retention, especially in those teachers who are new to the place(s) studied? Do affirmative behaviors and responses determined through ethnographic analysis correlate with quantitative evidence of improvement in knowledge and skills obtained through place-based learning? These questions can be addressed through continued application of ethnographic methods in qualitative or mixed-methods studies of larger populations over longer times.

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