The Geology of Mexico: A Quantitative Evaluation of a Course Designed to Increase the Number of Hispanic Students Participating in the Geosciences at California State University, Sacramento

Lisa C. Hammersley,[1,a] R. Levine,[2] K. Cornwell,[1] J. E. Kusnick,[1] and B. P. Hausback[1]

ABSTRACT

We present a quantitative evaluation of the effectiveness of a newly developed introductory course, Geology of Mexico, in attracting Hispanic students, encouraging them to take more geology courses, and recruiting them to the major. The student population in the Geology of Mexico course was 93% Hispanic compared with 18.5% in Physical Geology. We found that Hispanic students in Physical Geology earned lower grades than did nonminority students, while Hispanic students in Geology of Mexico earned grades comparable with nonminority students in Physical Geology. Overall, Geology of Mexico students also showed more positive attitude changes and were more likely to take another geology course. The recruitment rate into the major for Hispanic students in Geology of Mexico was 4.7% compared with 3% in Physical Geology. The recruitment rate for nonminority students in Physical Geology was 4.9%. We believe the difference in outcome for Hispanic students is due to a strong cohort effect enhanced by (1) the required lab component and (2) many students knowing one another because they belong to the Hispanic-serving organizations on campus that promote our course. © *2012 National Association of Geoscience Teachers*. [DOI: 10.5408/11-243.1]

Key words: diversity, Hispanic, STEM, place-based

INTRODUCTION

The lack of diversity in the science, technology, engineering, and mathematics (STEM) disciplines and, in particular, the geosciences has been recognized as a problem for many years (Huntoon and Lane, 2007; Velasco and de Velasco, 2010). Hispanics made up 16% of the U.S. population in 2009 and represent the most rapidly growing ethnic group in the nation (U.S. Census Bureau, 2011). However, the proportion of undergraduate degrees in science and engineering fields awarded to Hispanic students in 2007 was only 8%, and the proportion of earth science bachelor's degrees was only 3.5% (National Science Board, 2010). In California, Hispanics comprise 37% of the population (U.S. Census Bureau, 2010), and at California State University, Sacramento, 17% of the student population is Hispanic. Between 2005 and 2010, 61 students earned an undergraduate degree in geology from Sacramento State. Of these, 4 degrees were awarded to Hispanic students (6.5%). While this proportion is higher than the national average, the Geology Department at Sacramento State has long recognized a lack of diversity in its student population, as well as a need to increase the overall number of students in the major. In response to the national call for more diversity in the geosciences and with support from the National Science Foundation, a course called Geology of Mexico was designed and implemented. Our primary goal was to create an introductory geology course that would (1) be attractive to Hispanic students at Sacramento State, (2) create a fulfilling science experience for Hispanic students, and (3) encourage Hispanic students to (a) take more science courses and (b) consider majoring in the geosciences. We developed an evaluation plan to measure the effectiveness of the Geology of Mexico course in reaching these objectives. Here, we present a quantitative evaluation of the success of the Geology of Mexico course.

Received 19 May 2011; revised 27 December 2011; accepted 29 December 2011; published online 13 June 2012.

[1]Department of Geology, California State University–Sacramento, 6000 J Street, Sacramento, California 95819, USA
[2]Consultant, Redwood City, California 94062, USA
[a]Author to whom correspondence should be addressed. Electronic mail: hammersley@csus.edu.

DEVELOPMENT OF THE GEOLOGY OF MEXICO COURSE

The Geology of Mexico course was developed with the following goals: (1) attract Hispanic students to an introductory geology course and (2) create a fulfilling science experience for Hispanic students. The anticipated outcomes were that Hispanic students would (a) take more science courses and (b) consider majoring in the geosciences.

In thinking about how to draw Hispanic students into introductory geology classes, where they could then be recruited as majors, we took as our models successful place-based classes at other institutions (e.g., Tewksbury, 1995; Semken, 2005; Pujana et al., 2006). While these courses are still not common, there is some evidence that place-based science classes can improve student performance, motivation, and critical-thinking skills (Semken and Butler Freeman, 2008). Our primary goal was to attract students by connecting the study of geology to a geographic setting that resonated for the target students. Many Hispanic students in Northern California have family located in central Mexico, in particular the states of Michoacán, Guanajuato, and Colima, so organizing the course around the geology of Mexico while still retaining the essential components of an introductory geology course seemed the most promising strategy. In the end, we believe we produced a curriculum that is not a fully place-based course in the sense of Semken (2005), in which the culture and values of the place in question fully permeate

 © Nat. Assoc. Geosci. Teachers

the curriculum and students deeply interact with the localities under study. Instead, Geology of Mexico is essentially a thematic course, in which the introductory geology curriculum is taught through case studies with a common theme. However, we hoped to capture some benefits of place-based courses—an intrinsic connection between the students and the geology, an increase in motivation, and a sense for students that their personal or family history could connect with their role as a student at the university.

We initially concentrated on curriculum design. The starting point for development of Geology of Mexico was our more traditional introductory course, Physical Geology. As a result, Geology of Mexico is similar to Physical Geology in terms of both the geologic topics covered and the level of instruction. Geology of Mexico uses the same textbook as Physical Geology and follows the same sequence of topics, using regions of Mexico as the case studies. The only substantial difference between the lecture material covered in the two courses is that the topics of coastal processes and glaciers are not included in Geology of Mexico. This allows more detailed coverage of the case studies in the plate tectonic setting of Mexico, the mineral deposits of Mexico, and the Chicxulub impact.

The most important difference between the two courses is that the Geology of Mexico course has a required laboratory component, whereas concurrent enrollment in the lab for Physical Geology is not required. The lab for Physical Geology satisfies a general education physical science lab requirement, and about one-third of physical geology students take it concurrently with Physical Geology. However, the material covered in the two labs is similar. The Geology of Mexico labs follow a similar sequence of topics to the Physical Geology labs and were developed from the original lab material to be more relevant to Mexico. For example, the map-reading lab exercises use topographic maps from different areas of Mexico to teach the same concepts found in Physical Geology labs (reading map coordinates, using map scales, etc.).

Where possible, we incorporated real data from the literature. For example, one exercise uses earthquake foci to answer the question, "Why isn't the Mexican volcanic belt parallel to the Middle America Trench?" Students compare images of continental and island arcs from around the world with the configuration of the Mexican volcanic belt and observe that the volcanic front is not parallel to the trench as is common to most arcs. To explore the reasons for this, they take a map of earthquake foci in Mexico adapted from Pardo and Suarez (1995), color in the symbols for different depth ranges of foci, and then contour them, in effect, contouring depth to the Benioff Zone. Finally, they create two cross sections, plotting depth to earthquake foci against distance from trench, and compare the angle of subduction for the two subducting plates. This is similar to an exercise used to teach convergent plate boundaries in the Physical Geology lab. Many homework and exam questions used in the Physical Geology course and lab are also used in Geology of Mexico.

To insure that Hispanic students were aware of this new course, we worked closely with the College Assistance Migrant Program (CAMP), which serves students from migrant and seasonal farmworker backgrounds, and the Educational Opportunity Program (EOP), which serves California residents from low-income households. Discussions with these organizations helped us understand what would make the course most attractive and useful to students. We continue to work closely with both organizations, as well as other minority-serving organizations on campus.

The course has been offered every semester since spring 2007 except for the spring 2009 semester, when scheduling issues prevented it from being offered. During each fall semester, the Geology of Mexico course is offered as part of a freshman learning community through EOP. It is combined with a Chicano studies course, as well as a learning skills course. Enrollment in the Geology of Mexico course in the fall is initially limited to EOP students until their enrollment period has ended. In general, 20–24 of the 25 enrolled students are EOP students, and of these, more than 90% are Hispanic. During each spring semester, the course is open to all students.

This pattern of cohorting students with similar cultural and linguistic background was not part of our original course design. We had hoped that simply centering a course on Mexico would attract a greater proportion of Hispanic students. By working with CAMP and EOP, we secondarily created classes with a shared experience of culture, life, and school. While unintended, we believe this cohorting may be responsible for much of the success of Hispanic students in this culturally supportive environment.

METHODS

Research Questions

While the overall goal of the project was to increase the number of Hispanic students who choose to major in geology at Sacramento State, we examined two specific research questions:

(1) *Do Hispanic students learn more about geology in the Geology of Mexico class than in a traditional Physical Geology class?* We chose two methods of measuring student learning: comparison of grades between courses and use of a geologic knowledge assessment. Grades are important in student success and are easily obtained data. However, grades are also influenced by a range of factors that limit their utility in measuring learning, including student compliance with course requirements and varying grading standards across instructors. The use of an independent measure of student knowledge provides triangulation for grade data.

(2) *Do Hispanic students in the Geology of Mexico class develop more positive attitudes about geology than Hispanic students in a traditional Physical Geology course?* If our goal is to attract more Hispanic students into geology as a career, we reason that a course that produces improved attitudes may result in more students choosing to become geologists. We chose to measure changes in knowledge, attitudes, and behaviors that are associated with retention in a geoscience career pipeline (Levine et al., 2007).

We were concerned about three confounding variables that could influence our analysis. First, parental educational

attainment influences student success. If the demographics of students in the Geology of Mexico class differed from those of Hispanic students in the Physical Geology class, that difference could influence our results. Thus we designed our analysis to include the parental level of educational attainment for students in both classes.

We were also concerned that the Geology of Mexico class includes a lab component, while the lab is optional for the Physical Geology course. If participation in lab instruction plays a role in either how much geology students learn or how positively they feel about geology, it would impact our results. Our analysis was therefore designed to test the hypothesis that lab participation influences student performance and attitudes.

Finally, we wanted to be sure that any differences we saw were not the product of students taking prior geoscience courses. We expected students who had taken one geology course and decided to enroll in another to have more positive attitudes and greater geology knowledge than students who were taking their first geology course. For this reason, we also designed our analysis to identify students who had prior geology courses and to isolate the effect of this factor.

Instrument Design

To answer research question 1, a geoscience content knowledge test was developed to measure the extent of background knowledge and within-student changes (see the Knowledge Test available at: http://dx.doi.org/10.5408/11-243.s1). The knowledge test initially consisted of 11 questions. Of these, 7 questions were drawn from the Geoscience Concept Inventory (GCI; Libarkin, 2008) and 4 questions were drawn from typical Physical Geology exams used at Sacramento State. Because only 7 questions were drawn from the GCI, and because we included questions from another source, the knowledge quiz cannot be considered a validated GCI subtest. After administration of these knowledge items, we decided to remove two items from the analysis. One item instructed students to check all answers that apply but only had a single answer, confusing most students in both courses. A second item measured a construct not covered in the Geology of Mexico course (coastal processes).

To answer research question 2, a survey was developed to collect background demographic information, as well as to measure changes in attitudes associated with retention in a geoscience career pipeline (Levine et al., 2007). Student attitudes and beliefs were measured through use of "agree/disagree" items (see the Attitude Survey available at: http://dx.doi.org/10.5408/11-243.s2).

Data Collection

Data was collected during three semesters: spring 2007, fall 2007, and spring 2010. Data collection included the demographic/attitude survey, knowledge test, course grades, and courses taken by students prior to and following the semester in which they were surveyed. Table I summarizes which data were collected in each semester, as well as the course instructors. All data were collected in all semesters except in spring 2010, when the knowledge test was not administered. During the evaluation period, Geology of Mexico was taught by two instructors (Hammersley and Cornwell), and Physical Geology was taught by two instructors (Hammersley and Horner). All three faculty members work closely together and share lecture and exam materials. The textbook for both courses for all three semesters was the same. Finally, data on student grades and course-taking behavior were obtained through a review of administrative records.

Data Analysis

Data were entered into Microsoft Excel spreadsheets, with 100% verification. The Excel spreadsheets were used to create SAS data files and analyses were conducted using SAS version 9.2. Comparisons of student responses at the beginning and the end of the semesters allowed us to assess within-student changes and to compare these changes across the different courses. "Strongly agree" responses were assigned a value of 1.5, "agree" responses were assigned a value of 0.5, neutral responses were assigned a value of 0, "disagree" responses were assigned a value of −0.5, and "strongly disagree" responses were assigned a value of −1.5. This numerical coding treated responses as though they were continuous variables, with the distance between "strongly agree" and "agree" responses equivalent to the difference between "agree" and "disagree" responses (i.e., as in an interval scale). By assigning a value of 0 to neutral responses, positive mean values indicated overall agreement while negative values indicated overall disagreement.

Within-student changes were assessed through dependent *t*-tests using PROC MEANS; average scores (and average change scores) across groups were compared using PROC TTEST or PROC GLM. Categorical variables were compared through chi-square tests using PROC FREQ. A criterion of $p < 0.05$, two tailed, was used to determine statistical significance.

Within each course, subgroup analyses by race/ethnicity (White/Asian, Hispanic, and other minority) and by parental educational attainment were conducted. Since participation in prior geology courses might influence student knowledge scores, additional analyses were conducted only for students with no prior geology courses. Analyses of the Physical Geology course also compared students who were taking a concurrent geology lab course with those who were not.

RESULTS: SURVEY FINDINGS

Student Demographics

The Geology of Mexico course has been highly successful in attracting Hispanic students. Of the 69 students who reported their race in the three semesters surveyed, 93% identified themselves as Hispanic, 3% as White or Asian, and 2% as other minority (Fig. 1). We expected a high Hispanic enrollment in the fall semesters, when enrollment is initially limited to EOP students. However, we have also seen a high Hispanic enrollment when enrollment is not limited to this largely minority group of students. In the spring 2007 and 2010 semesters, when the course was open to all students, enrollment was 91% Hispanic compared to 96% Hispanic in fall 2007. In contrast, the ethnicity of students in Physical Geology closely represents the diversity of the university; of the 178 students who reported their race, 19% identified themselves as Hispanic, 73% as White or Asian, and 8% as other minority.

TABLE I: Summary of data collection for this study.

	Semester					
	Spring 2007		Fall 2007		Spring 2010	
Course	Physical Geology	Geology of Mexico	Physical Geology	Geology of Mexico	Physical Geology	Geology of Mexico
Instructor	Hammersley	Hammersley	Horner	Hammersley	Horner	Cornwell
Data collected	Attitude survey	Attitude survey	Attitude survey	Attitude survey	Attitude survey	Attitude survey
	Grades	Grades	Grades	Grades	Grades	Grades
	Course records	Course records	Course records	Course records	Course records	Course records
	Knowledge test	Knowledge test	Knowledge test	Knowledge test		

The development of strong partnerships with CAMP and EOP during the development and initial offering of the Geology of Mexico course contributed to our success in attracting Hispanic students, particularly students whose parents did not attend college. Figure 2 shows, by race/ethnicity, the highest reported level of educational attainment for either parent for students in these classes. (Since 96% of Geology of Mexico students were Hispanic, there were not enough non-Hispanic students for us to produce stable estimates of non-Hispanic student characteristics.) In the Geology of Mexico course, 79% of Hispanic students enrolled had parents with high school or less education. Only 21% had parents with some college education, and only 5% had at least one parent with a college degree. Conversely, in Physical Geology, 62% of Hispanic students had parents with some college-level or higher education. The Geology of Mexico course not only attracts more Hispanic students but also attracts a group of students not strongly represented in our other introductory courses. This is almost certainly due to our promotion of the Geology of

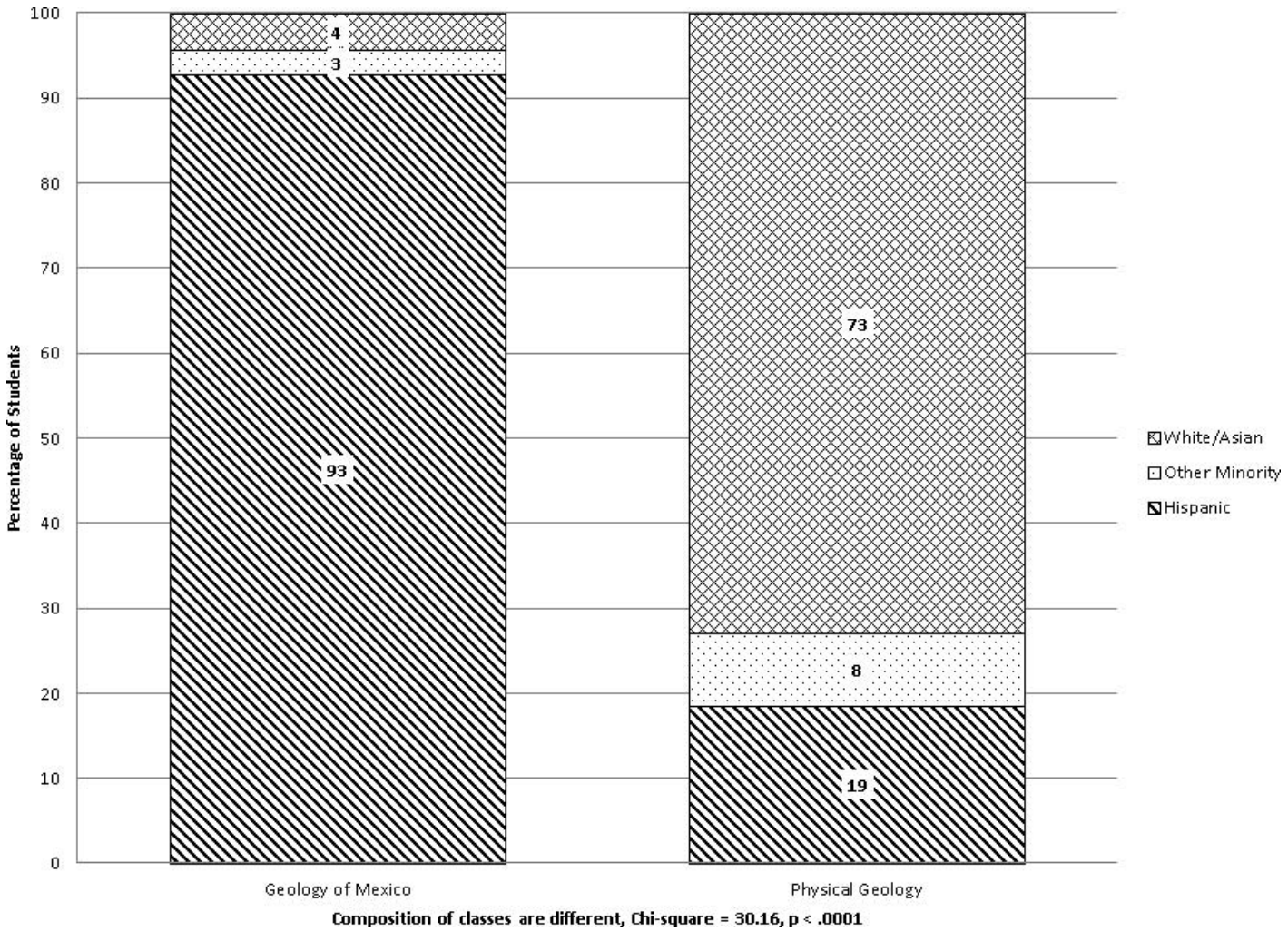

FIGURE 1: Racial/ethnic composition of Geology of Mexico and Physical Geology for the spring 2007, fall 2007, and spring 2010 semesters.

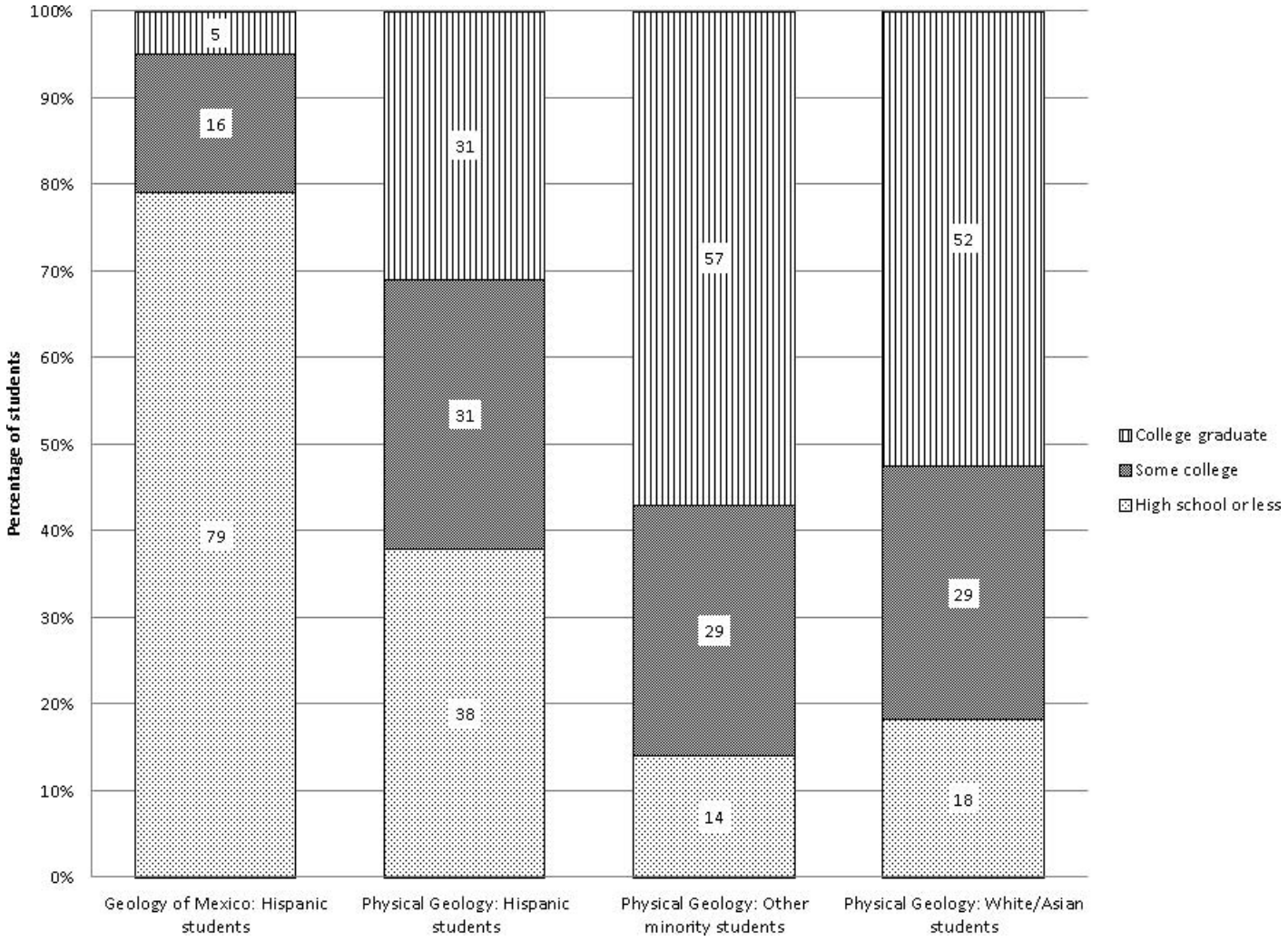

FIGURE 2: Parental education by race/ethnicity for Geology of Mexico and Physical Geology.

Mexico course through CAMP on campus and is not a result of enrollment restrictions during the fall semester, when the course is offered as part of an EOP learning community. We see no significant difference in reported parental educational attainment between Hispanic students surveyed in Geology of Mexico during fall 2007 and those surveyed in the spring 2007 and 2010 semesters, when enrollment was open to all students.

Student Performance

We assessed student performance in Physical Geology and Geology of Mexico using a knowledge test administered at the beginning and end of the spring and fall 2007 semesters.

Figure 3 shows the results of the tests given at the beginning (pre) and end (post) of the semester for each course. Forty-two students in Geology of Mexico and 54 students in Physical Geology completed both the pre- and the posttests. However, to ensure we were assessing the impact of the two courses being evaluated, only students who had no prior geology courses were included in this analysis (40 Geology of Mexico students and 53 Physical Geology students). Results are presented by race/ethnicity for Physical Geology students. In Geology of Mexico, only data for Hispanic students is included, because none of the non-Hispanic students completed both the pre- and the posttests. The results of the pretest showed that regardless of ethnicity, students in Physical Geology scored significantly higher than those in Geology of Mexico, answering an average of 5.40 out of 9 items correctly, compared with 3.25 correct answers for students in the latter course ($t = 2.47$, $p = 0.017$). At the end of the semester, Physical Geology students overall had significantly higher scores than Geology of Mexico students (6.04 versus 4.98 items correct, $t = 2.74$, $p = 0.008$). Both Geology of Mexico students and Physical Geology students showed significant knowledge gains (Geology of Mexico: 1.73 items, $t = 5.98$, $p < 0.0001$; Physical Geology: 0.64 items, $t = 2.25$, $p = 0.031$). The average increase in score for Geology of Mexico students was significantly greater than the increase for Physical Geology students ($t = 2.83$, $p = 0.007$).

We conducted additional analyses of the knowledge items and changes in knowledge items for Physical Geology students as a function of parental educational attainment and ethnicity for students who had not taken prior geoscience courses (see the Supplemental Data file available at: http://dx.doi.org/10.5408/11-243.s3). Knowledge pretest, posttest, and change scores were not significantly different

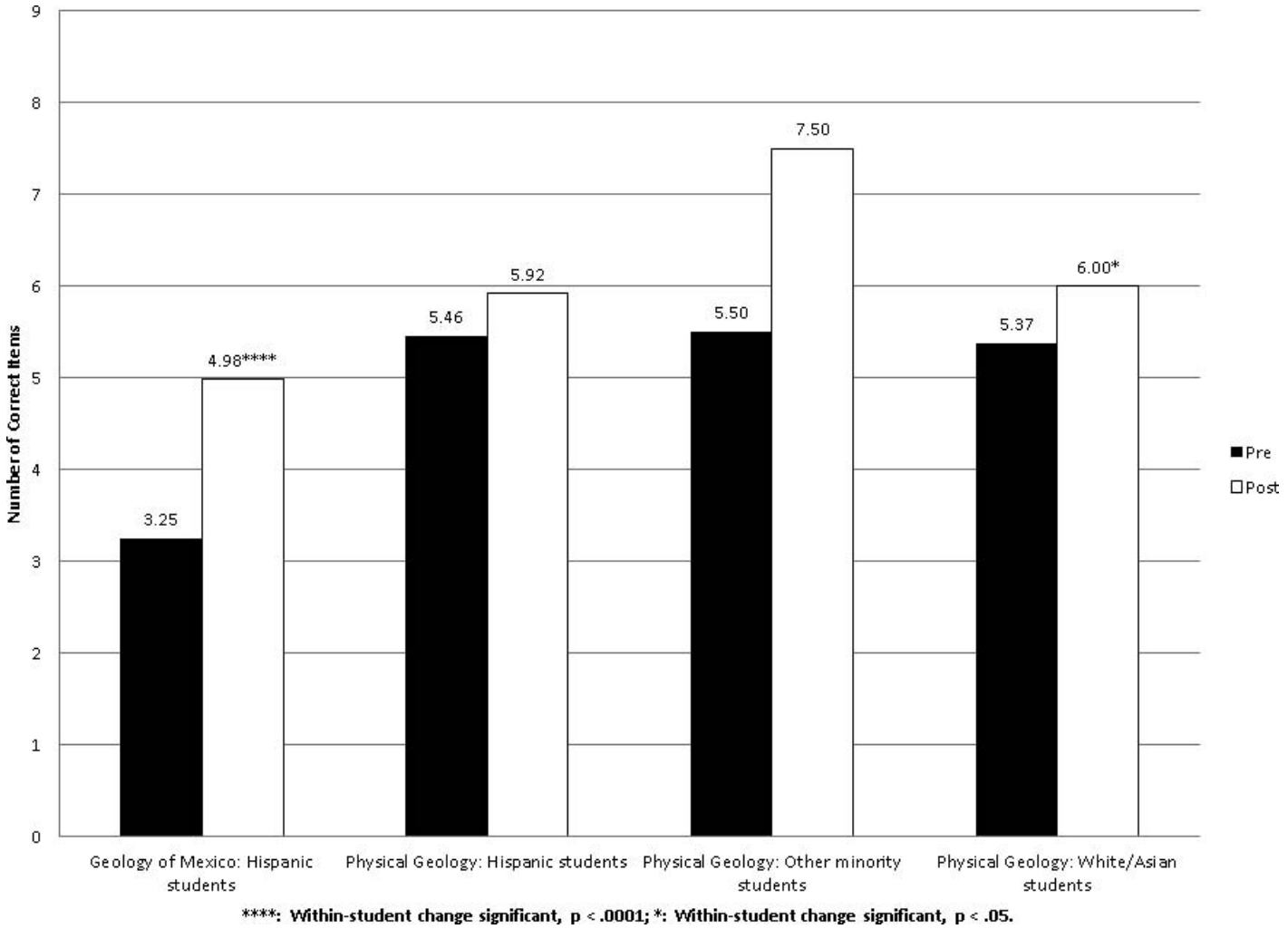

FIGURE 3: Knowledge test scores before and after the course. Students in Physical Geology are grouped by race/ethnicity.

as a function of ethnicity (Hispanic versus White or Asian students). Although the White and Asian students showed statistically significant within-student improvements (+0.64, $t = 2.25$, $p = 0.031$), Hispanic student's improvements were not statistically significant (+0.46, $t = 0.72$, $p = 0.482$). However, there were only 13 Hispanic students in this analysis, substantially decreasing our power for detecting change.

Similarly, knowledge pretest, posttest, and change scores were not significantly different as a function of parental educational attainment (one parent with at least some college versus no parents with at least some college). The higher parental educational attainment students showed statistically significant within-student improvements (+0.56, $t = 2.07$, $p = 0.045$). Although the improvements of students with lower parental educational attainment were larger in absolute terms (+0.90 versus +0.56), these improvements were not statistically significant ($t = 1.26$, $p = 0.244$). This reflects that only 10 students did not have at least one parent with some college education in this analysis, substantially decreasing our power for detecting change.

As another measure of student performance, final course grades were collected for the spring 2007, fall 2007, and spring 2010 semesters. Table II shows a comparison of the final course grades, expressed as grade point averages, earned by students in Physical Geology and Geology of Mexico. The average grade for the Geology of Mexico course was 3.12 (3.16 for students with no prior geology experience). For all students in Physical Geology, the average grade was 2.87. The average grade for White and Asian students in this course was significantly higher than the average for Hispanic students (3.00 versus 2.52, $t = 2.34$, $p = 0.02$). When considering only Physical Geology students with no prior geology experience, the results were similar, with the average grade for White and Asian students remaining significantly higher than the average grade for Hispanic students (3.02 versus 2.45, $t = 2.58$, $p = 0.011$).

To control for Geology of Mexico's required lab component, we also considered only those students in Physical Geology (with no prior geology experience) who were concurrently enrolled in the optional lab course. The average grade for those students was higher than the average grade for similar students not enrolled in a concurrent lab course (2.99 versus 2.77), but these average grades were not significantly different from each other ($t = 1.18$, $p = 0.241$). However, the differences in performance

TABLE II: Final course grades for students in Physical Geology and Geology of Mexico by race/ethnicity.[1,2]

	Physical Geology (all)	Physical Geology (no prior)	Physical Geology + Lab (no prior)	Physical Geology (no lab, no prior)	Geology of Mexico (all)	Geology of Mexico (no prior)
White/Asian	3.00 (129)	3.02 (105)	3.15 (39)	2.94 (66)	2.56 (3)	2.00 (2)
Hispanic	2.52 (33)	2.45 (31)	2.70 (12)	2.30 (19)	3.15 (64)	3.20 (58)
Other minority	2.56 (15)	2.56 (15)	2.42 (4)	2.61 (11)	3.00 (1)	3.00 (1)
Average	2.87 (177)	2.85 (151)	2.99 (55)	2.77 (96)	3.12 (68)	3.16 (61)

[1]Numbers in parentheses are the number of students in each group.
[2]Data from spring 2007, fall 2007, and spring 2010.

between the White and Asian students and all other minority students (i.e., Hispanics and other minorities) taking the concurrent lab course approached statistical significance (3.15 versus 2.63, $t = 1.97$, $p = 0.054$).

Minority students in Physical Geology appear to score half a grade point lower than nonminorities, whether or not they take the lab and regardless of instructor. The difference in grade between White or Asian and Hispanic students is 0.48 for all students, 0.45 for students who took the lab, 0.44 for students taught in spring 2007 by Hammersley, and 0.49 for those taught in fall 2007 and spring 2010 by Horner.

Student Attitudes

Students were asked to indicate their level of agreement with a number of statements regarding their attitudes toward and understanding of geology as a career path. To control for differences in background, we conducted analyses of Physical Geology students' attitudes as a function of ethnicity, whether or not students were taking a geology lab concurrently with the course and whether or not students had taken prior geoscience courses. We were able to perform this analysis for the survey data because the number of students completing the survey (both pre and post) was greater than the number of students completing the knowledge test due to the inclusion of spring 2010.

Students in both courses reported statistically significant and more positive attitudes toward nearly all geoscience items at the end of the semester (Table III). The most significant changes were apparent in responses to the statements "I know the courses and degrees necessary to become a geologist," "I'd enjoy a career in geology," "I have a good idea of what geologists do at work," and "I know about the different kinds of careers that hire people with geology degrees." For nearly all statements, the improvement in attitudes was greater for students in Geology of Mexico than it was for students in Physical Geology. For the statement "I plan on taking additional classes in geology," students in both courses initially showed slight disagreement. By the end of the semester, students were more likely to agree with this statement, with the students in Geology of Mexico showing statistically significant positive changes ($p < 0.002$).

Attitudinal items were strongly associated with whether or not a student had taken a prior geoscience class. For all pretest attitudinal items, students who had taken a prior geoscience class had significantly higher (more favorable) attitudes than those who had not taken prior geoscience

TABLE III: Responses to selected statements by students from Geology of Mexico and Physical Geology during spring 2007, fall 2007, and spring 2010.[1,2]

	Physical Geology ($n = 119$)					Geology of Mexico ($n = 61$)				
	Pre	Post	Diff	t	p	Pre	Post	Diff	t	p
I know the courses and degrees necessary to become a geologist.	−0.54	0.19	0.73	8.11	<0.0001	−0.84	−0.03	0.81	6.19	<0.0001
I'd enjoy a career in geology.	−0.16	0.16	0.32	4.74	<0.0001	−0.31	0.22	0.53	5.72	<0.0001
I know about the different kinds of careers that hire people with geology degrees.	−0.25	0.48	0.74	9.16	<0.0001	−0.65	0.12	0.77	6.20	<0.0001
Most geologists earn good incomes.	0.11	0.39	0.28	5.41	<0.0001	0.16	0.42	0.26	2.73	0.0083
I have a good idea of what geologists do at work.	0.08	0.57	0.49	7.24	<0.0001	0.05	0.70	0.65	5.20	<0.0001
Geology is a respectable career.	0.90	1.10	0.20	3.31	0.0012	0.76	1.12	0.36	4.08	0.0001
My friends would encourage me if I chose to major in geology.	0.30	0.62	0.32	4.52	<0.0001	0.46	0.78	0.33	3.20	0.0022
My family would encourage me if I chose to major in geology.	0.42	0.71	0.29	4.19	<0.0001	0.60	0.96	0.36	3.92	0.0002
I plan on taking additional classes in geology.	−0.08	0.04	0.13	1.72	0.0885	−0.04	0.28	0.32	3.16	0.0024
I am interested in participating in a geologic research project.	−0.01	−0.05	−0.05	0.62	0.5364	0.30	0.30	0.01	0.09	0.9266

[1]Strongly agree = 1.5; agree = 0.5; disagree = −0.5; strongly disagree = −1.5.
[2]pre = beginning of semester, post = end of semester, diff = difference.

classes. Similarly, for all but one of the items, the experienced geoscience students had significantly more positive attitudes at the end of the class than the first-time geology students. However, the overall changes in attitudes for the two groups were not statistically different from each other (see the Supplemental Data file available at: http://dx.doi.org/10.5408/11-243.s3).

Whether or not a student was taking the lab course concurrently with Physical Geology was unrelated to either pre- or postcourse responses to any attitudinal items or to changes in any of these attitudes (see the Supplemental Data file available at: http://dx.doi.org/10.5408/11-243.s3). Within each of these groups (i.e., taking a concurrent lab course versus not taking a concurrent lab course), there was no evidence that attitude change was a function of ethnicity. And for those not taking a concurrent lab course, there was only weak evidence of attitude change as a function of ethnicity: For only one of the attitudinal items was there differential change. (White or Asian students not taking a concurrent lab course were more likely to show gains in their response to the item stating "I know the courses and degrees necessary to become a geologist.")

One inference that could be drawn from this is that students who take Geology of Mexico are more likely to take another geology course than are students who take Physical Geology. To test this hypothesis, we tracked the courses taken by students who took either class during the spring 2007, fall 2007, and spring 2010 semesters. For each student, we tabulated all geology courses they had taken previously at Sacramento State and any geology courses they took subsequently. When calculating the proportion of students who took subsequent geology courses, we only included those who had not taken prior geology courses. This was to ensure that we were tracking the effect of the course in question on comparable students. Table IV shows these results. Geology of Mexico served 61 students who had no prior geology courses (2 White/Asian, 57 Hispanic, 2 other minority). Of these students, 18 (29.5%) went on to take subsequent geology courses. All 18 were Hispanic, representing 31.6% of the Hispanic students who took the course. In comparison, Physical Geology served 152 students who had not taken any geology course (106 White/Asian, 31 Hispanic, 15 other minority). Of these, 30 (19.7%) went on to take another geology course. Of the 31 Hispanic students in Physical Geology, only four went on to take another geology course, a rate of 12.9% compared to 20.7% for White and Asian students.

Another indicator supporting the attitude change data is the number of students majoring or minoring in geology after taking either Physical Geology or Geology of Mexico. Of the 171 nonmajors who took Physical Geology during the semesters being assessed, 7 subsequently declared a major or minor in geology, a recruitment rate of 4.0%. Of these, 6 reported their race/ethnicity as White or Asian and 1 reported his or her race as both Hispanic and White and was considered Hispanic for this study. (However, this was an upper-middle-class student whose parents both had a PhD, whose name was not Hispanic, and who functioned as a member of the majority culture.) These numbers can be translated into recruitment rates of 4.9% for White or Asian students and 3.0% for Hispanic students. In comparison, 69 nonmajors took Geology of Mexico, and 3 of these students later declared a major or minor in geology (4.4%). All three of these students were Hispanic, giving a 4.7% recruitment rate for Hispanic students, comparable to the recruitment rate for nonminority students in Physical Geology and higher than the rate for Hispanic students in Physical Geology.

In all semesters in which the Geology of Mexico course has been offered—the three semesters studied here and five others—eight students have declared a major in geology and one has declared a minor. In fall 2011, four students from Geology of Mexico were taking Historical Geology, the next lower division course required for the major. This is the first time Geology of Mexico recruits have formed a cohort within the major. We cannot report the number of Hispanic majors recruited from Physical Geology because we do not carefully track the ethnicity of all new geology majors or their path to the major (i.e., transfer students versus those recruited from entry-level courses such as Physical Geology). However, geology is a small major, and the eight students recruited from the Geology of Mexico course appear to be the only Mexican American majors. The first students we recruited reported a sense of isolation from the other majors due to their race.

DISCUSSION

The overall goals of this project were to increase the number of Hispanic students taking introductory geology courses and ultimately increase the number who chose to major in geology at Sacramento State. To assess the effectiveness of the Geology of Mexico course, we examined two specific research questions: (1) Do Hispanic students learn more about geology in the Geology of Mexico class than in a traditional Physical Geology class? (2) Do Hispanic students in the Geology of Mexico class develop more positive attitudes about geology than Hispanic students in a traditional Physical Geology course?

TABLE IV: Subsequent geology courses taken by students in Physical Geology and Geology of Mexico who had not taken prior geology courses.

	Physical Geology			Geology of Mexico		
	Students With No Prior Geology	Students Who Took Subsequent Geo Courses	%	Students With No Prior Geology	Students Who Took Subsequent Geo Courses	%
White/Asian	106	22	20.7	2	0	0
Hispanic	31	4	12.9	57	18	31.6
Other minority	15	4	26.7	2	0	0
Total	152	30	19.7	61	18	29.5

Our data clearly demonstrate the success of the Geology of Mexico course in attracting Hispanic students, particularly those whose parents did not attend college. Close communication with organizations such as CAMP and EOP were integral to this success. CAMP advisors recommend Geology of Mexico to their incoming students, but they also reported to us that many of their students were already planning on taking the course because it is the only science course based on Mexico. CAMP advisors reported that positive experiences have led to strong positive word of mouth about the Geology of Mexico course and, by extension, other geology general education offerings.

Students enrolling in Geology of Mexico scored lower on a geologic knowledge pretest than students in Physical Geology. We cannot explain this result, because there were no significant relationships between knowledge scores of students and either race or parental education. Despite the low initial scores, Geology of Mexico students showed significant gains in knowledge over the course of the semester, and many earned high grades. As previously noted, the Hispanic students in Physical Geology earned grades significantly lower than those of the White or Asian students. We further found that Hispanic students were earning higher grades when in Geology of Mexico. Given the similarity between the two courses, we believe the significant difference in performance of Hispanic students in Physical Geology and Geology of Mexico could be attributed to a number of factors, including the following:

(1) Many students in Geology of Mexico typically come from CAMP and often know one another before coming into the class. In addition, almost everyone in the class is a member of the same linguistic and cultural community. This cohort effect makes students more comfortable speaking out during lecture, asking questions, and working in groups. Those with language difficulties are not as self-conscious and are comfortable speaking out in class. We often see students in Geology of Mexico explaining the material in Spanish to those with language difficulties.
(2) The Geology of Mexico course includes a required lab course, taught by the same faculty member, while Physical Geology has a lab course that is not required. The close connection between lecture material and lab exercises helps students reinforce their learning by including hands-on activities. In a study of the effects of small group learning, Springer et al. (1999) showed that cooperative learning in small groups had a positive effect for all students but that this positive effect was significantly greater for small groups composed primarily of African Americans and Latinos when compared with predominantly White or relatively heterogeneous groups.

We have shown previously that Physical Geology students who also took the lab did not show statistically significant differences in grades or attitude changes when compared with those who only took the lecture course. However, the Physical Geology lab experience is not the same as the Geology of Mexico lab experience. In Physical Geology, is it usually a different faculty member teaching the lab and a different group of students taking the lab. Both the close connection with the lecture material and the cohorting effect are reduced.

We believe that these two factors taken together—the cohort of students, many already known to one another, with similar cultural and linguistic backgrounds and their experience in working together to solve geologic problems set in a place of intrinsic interest to them—combined to create a true community of practice (Lave and Wenger, 1991). Communities of practice are natural associations of people who are engaged in a joint enterprise, who function through mutual engagement, and who use a shared repertoire of communal resources developed by the members of the community. Educators have increasingly looked to the development of communities of practice as a way of increasing school performance in underachieving groups (e.g., Aguilar and Krasny, 2011). The underlying logic is that learning requires social support, which can be nurtured through the intentional development of communities of practice in the classroom.

In attracting and retaining Hispanic students in the geosciences, we must confront the larger issue of retention of these students in the university. Causes for the lack of persistence in higher education by Hispanic students include financial reasons, lack of mentors, hostile campus climates, and a sense of cultural misfit (Gloria et al., 2005). We did not set out to address all of these factors, but in the end we made inroads into several of them. Students interacted closely with geology faculty members, who adopted the role of mentors. We chose to focus on Mexico to improve the sense of cultural fit for this population of students. Perhaps the most intriguing outcome of the Geology of Mexico course is that we inadvertently promoted the development of a community of practice that supplied precisely the social support required by first- and second-generation Hispanic students, improving classroom climate and a sense of cultural continuity between school and home culture. Students spontaneously organized themselves into groups supportive of individual students' language needs. A collaborative climate rapidly developed among the students, with a degree of cooperative interaction rare in introductory college classes. The students themselves created the environment in which Hispanic students, regardless of their language abilities or experience in American culture, could safely learn.

We believe this is why students who take the Geology of Mexico course are significantly more likely to take at least one other geology course than Hispanic students who take Physical Geology. We believe this is due to the positive experience many students have expressed having in the Geology of Mexico course, also reflected in their responses to the attitudinal questions, and their strong performance in the class, reflected in their final grades. Baber et al. (2010) describe factors that influence student self-efficacy—a sense of one's ability. These factors include experiencing success, seeing others succeed, being verbally persuaded of one's ability, and altering misinterpretations of stress indicators. We believe that the small class setting of Geology of Mexico, the incorporation of lab exercises carefully structured to build upon successes, and the use of teaching assistants as role models may combine to ensure not only that the students enjoy the course but that they leave feeling they were capable of pursuing further courses or even a degree in the geosciences.

CONCLUSIONS

Huntoon and Lane (2007) outline best practices for attracting underrepresented minority students to the geosciences. These include (1) demonstrating relevance of the field, (2) forming partnerships with multiple stakeholders, (3) promoting strong mentorship relationships, and (4) providing financial assistance. The Geology of Mexico course serves three of these four needs. As a result, the course has had a significant impact in terms of attracting Hispanic students to the geosciences. We believe the performance of Hispanic students in Geology of Mexico was enhanced through lab exercises and cohorting in helping students succeed. Hispanic students who might have felt isolated or unwilling to speak up in Physical Geology actively engaged in course material in Geology of Mexico. As a result, students in Geology of Mexico have generally shown more positive shifts in attitudes to geology than did students in Physical Geology, and a greater proportion of them go on to take subsequent geology courses than the proportion of students from Physical Geology, particularly Hispanic students from Physical Geology.

Since the course was first offered in spring 2007, eight students have declared a major in geology after taking Geology of Mexico and one has declared a minor. While the combined number is still quite small, the impact is relatively great. In 2007, only 113 U.S. bachelor's degrees in earth science were awarded to Hispanic students (National Science Board, 2010). Just one additional Hispanic student graduating with a geology degree as a direct result of our program represents an almost 1% increase nationally.

Place-based courses have been shown to be effective at attracting minority students to the geosciences. However, we find it noteworthy that the Geology of Mexico course was closely modeled on the traditional Physical Geology courses and lab, using Mexican case studies to illustrate the concepts. This is a more traditional delivery than many of the models in the literature, yet it is also successful at attracting Hispanic students and retaining their interest in the geosciences. Close communication with Hispanic-serving organizations on campus has been crucial to that success.

Acknowledgments

This study was funded by the National Science Foundation's Opportunities for Enhancing Diversity in the Geosciences program (NSF GEO-0503375). The authors thank the two anonymous reviewers and the editor and associate editor at the *Journal of Geoscience Education* for their constructive comments, which helped improve this manuscript.

REFERENCES

Aguilar, O.M. and Krasny, M.E. 2011. Using the communities of practice framework to examine an after-school environmental education program for Hispanic youth. *Environmental Education Research,* 17:217–233.

Baber, L.D., Pifer, M. J., Colbeck, C., and Furman, T. 2010. Increasing diversity in the Geosciences: Recruitment programs and student self-efficacy. *Journal of Geoscience Education*, 58:32–42

Gloria, A.M., Castellanos, J. and Orozco, V. 2005. Perceived educational barriers, cultural fit, coping responses, and psychological well-being of Latina undergraduates. *Hispanic Journal of Behavioral Sciences*, 27:161–183.

Huntoon, J. E. and Lane, M. J. 2007. Diversity in the geosciences and successful strategies for increasing diversity. *Journal of Geoscience Education*, 55:447–457.

Lave, J., and Wenger, E. 1991. Situated learning: Legitimate peripheral participation. New York: Cambridge University Press. p. 138.

Levine, R., González, R., Cole, S., Furhman, M., and Carlson le Floch, K. 2007. The geoscience pipeline: A conceptual framework. *Journal of Geoscience Education*, 55:458–468.

Libarkin, J.C. 2008. Concept Inventories in Higher Education Science. Presented at National Research Council Promising Practices in Undergraduate STEM Education Workshop 2. Available at http://www7.nationalacademies.org/bose/Libarkin_CommissionedPaper.pdf (accessed 29 February 2012).

National Science Board. 2010. Science and engineering indicators 2010. Arlington, VA: National Science Foundation (NSB 10-01).

Pardo, M., Suarez, G. 1995. Shape of the subducted Rivera and Cocos plates in southern Mexico: seismic and tectonic implication. J*ournal of Geophysical Research,* 100:12,357–12,373.

Pujana, I., Stern., R., and Ledbetter, C. 2006. Geology, resources and environment of Latin America: Incorporating Earth systems science education in an undergraduate science service course intended for Hispanic students. *Journal of Geoscience Education*, 54:357–363.

Semken, S. 2005. Sense of place and place-based introductory geoscience teaching for American Indian and Alaska Native undergraduates. *Journal of Geoscience Education*, 53:149–1573.

Semken, S. and Butler Freeman, C. 2008. Sense of place in the practice and assessment of place-based science teaching. *Science Education,* 92:1042–1057.

Springer, L., Stanne, M.E., and Donovan, S. 1999. Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research,* 69:21–51.

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

U.S. Census Bureau, 2011, Statistical abstract of the United States (130th Edition). Washington, DC: U.S. Government Printing Office.

U.S. Census Bureau. 2010. State and county QuickFacts. Available at quickfacts.census.gov/qfd/states/06000.html (accessed 26 December 2011).

Velasco, A. A., and de Velasco, E. J. 2010. Striving to diversity the geosciences workforce. *EOS Trans. AGU,* 91(33):289–290.