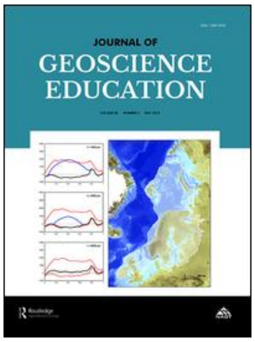

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Understanding Perceptions of the Geosciences Among Minority and Nonminority Undergraduate Students

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ABSTRACT

This study augments existing literature in understanding student perceptions about the geosciences; we examined the choice of major and science courses taken by 645 students at a large southeastern research university. Differences were examined between underrepresented minority (URM) and nonminority students. We compared responses regarding not only different sciences but also different subfields of geoscience, and where possible, we compared those subjects with biology. Our results show significant differences in (1) the selection of a college major, (2) the selection of science electives, (3) characteristics of the ideal career, (4) interest and self-efficacy in science and math, and (5) career perceptions of geoscience and other select sciences among URM and nonminority students. We identified three main factors that contributed to student selection of college major, including *important influencers*, *sustained identification with or interest in that major*, and *descriptors of the major* itself. We also found that a student's advisor may be one of the greatest factors in which science classes an undergraduate student takes at a university. Finally, our research showed that the geosciences scored lower than other science subjects with respect to student perceptions in its ability to *help the environment*, *help society*, *help them find a job*, and *salary*. This was true for each of the geoscience fields measured when compared with every other science, technology, engineering, and math fields measured with the exception of physics. © *2016 National Association of Geoscience Teachers*. [DOI: 10.5408/15-112.1]

Key words: diversity, career knowledge, choice of major

INTRODUCTION

Successful efforts to recruit a diverse geoscience workforce are essential to the future of the field. From 1989 to 2007, bachelor's degrees in biology increased, whereas physical science degrees remained flat, and earth science degrees declined (National Science Board, 2010). The exception to the decrease in earth science degrees was in meteorology, which saw an increase. However, workforce trends in geoscience fields have demonstrated a national need with most geoscientists in the workforce within 15 y of retirement age and 12% to retire by 2018 (Perkins, 2011). The American Geosciences Institute predicts a shortage of approximately 135,000 geoscientists by the end of this decade, and this pending need appears to be facing all of the federal geoscience workforce, except meteorology (AGI, 2014). We face a critical juncture in which to address these geoscience workforce needs. At the same time, the proportion of nonwhite individuals entering the workforce is increasing (Toossi, 2012), emphasizing the need to broaden participation in the field. Geosciences rank among the least ethnically diverse science, technology, engineering, and math (STEM) fields (Stokes et al., 2015). Efforts to recruit more students in general, as well as talented, underrepresented populations, to the geosciences have encountered many barriers and limited success, despite targeted efforts across funding agencies and educational organizations. Research focusing on perceptions among geoscientists and nongeoscientists and among minority and nonminority students has served to inform educators in understanding the cultural, educational, and institutional barriers that need to be overcome to improve recruitment, retention, and success in the geosciences, specifically among underrepresented groups (Fields, 1998; Baker, 2000; Wenner, 2003; Fadigan and Hammrich, 2004; Whitney et al., 2005; Lewis and Baker, 2010; O'Connell and Holmes, 2011).

One of the reasons attributed to geoscience's leaky career pipeline is a lack of exposure. Less exposure is manifest in the failure to identify with geoscience role models, which is especially true for minority students, and the dearth of earth and space science courses in high school (Lewis and Baker, 2010), which confronts students of all races. Providing information about the geosciences to students who may not initially consider a geoscience career is most effective when delivered by a role model with a similar background or appearance as the student (Huntoon and Lane, 2007). Access to role models has been reported as a pipeline factor across STEM fields (Levine at el., 2007). The lack of minority role models may have historically kept minority students away from environmental science and other biological science careers, with the exception of medical careers and nursing (Ashbacher et al., 2010; Baker, 2000). Similarly, the fewer geoscience graduates reduce the availability of a geoscientist, and especially a minority geoscientist, to serve as a role model for a young student (Levine et al., 2009).

In high school, students are also more likely to have courses in biology, chemistry, or physics than they are courses in earth science (Gonzales, 2009; Gonzales and Keane, 2010), leading to decreased student interest and awareness of the geosciences relative to other fields (Wenner, 2003; Levine et al., 2007). When asked to describe each of five sciences, elementary school students were best

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able to describe biology and were less able to describe geology and ecology; male students at a lower-income elementary school scored the worst in their descriptions of geology (Wenner, 2003). Biology was the most frequently named science (named by 19%) when talented, female, high-school students from low-income homes were asked about their desired career (Fadigan and Hammrich, 2004). Meteorology and environmental careers were only listed by two participants (4%) in that study (Fadigan and Hammrich, 2004). Previous research also indicated a significant difference among science teachers in their knowledge of geoscience and biology careers and majors (Sherman-Morris et al., 2013), indicating the divide between geoscience and biological science knowledge persists beyond low-income and/or minority students.

The lack of awareness and misperceptions about the geosciences are more pronounced among minority students. In addition to unfamiliarity, Fields (1998) suggests African American students perceive geoscience careers as not helping the black community. Eccles (1994) found that adolescents who valued helping others tended not to aspire to a physical science career. The ability to affect one's community and good job potential often attract minority students to medical fields (Baker, 2000). Hispanic students also showed a lack of familiarity with the geosciences, but in a study of both high school and college students, the lack of encouragement to study the geosciences was perceived to be the greatest among African American students (Whitney et al., 2005).

Both the desire for a career that will help the community and more exposure to biology in high school often lead to a preference for biology among minority students who enroll in STEM majors. Because of the differences noted earlier between meteorology and other geoscience fields, it is unclear whether careers or majors in all geoscience subfields (in this article, meteorology, geology, and geography) are understood or perceived similarly. Meteorology provides the public face of science for many, through television weathercasters (Wilson, 2008). It is possible that meteorology, therefore, may be perceived and better understood, similar to biology, than other geoscience subfields are.

The current study examined the choice of major and science courses chosen by 645 students at a large, southeastern research university. Differences were examined between underrepresented minority (URM) students and nonminority students, who are defined in this article as white or Asian. Although *Asian* is often considered a minority category, it is not typically considered an *underrepresented* minority category with respect to geoscience enrollment and career attainment. This definition was true for the program that funded this project. A component of this project that makes it different from previous studies was the effort made to compare responses regarding not only different sciences but also different subfields of geoscience and, where possible, to compare those subjects with biology. There is a community effort to increase diversity in the geosciences; however, it may not be appropriate to treat the geosciences as a single entity during recruitment strategies that attempt to broaden participation. This article, therefore, attempts to dig deeper into the specific differences perceived among geography, meteorology, and geology with other STEM fields, including chemistry, biology, physics, and engineering. We specifically sought to address the following research questions:

(1) How did students arrive at their major, and what are important factors for bringing underrepresented populations to the geoscience field?
(2) What are the perceived differences between the geosciences and other STEM subjects among URM and nonminority undergraduate students?
(3) How are the separate geoscience disciplines perceived by URM and nonminority undergraduate students?

METHODS

This research was conducted through a pencil-and-paper survey using the procedures described below. Human subjects' research approval was received by the university institutional review board before research commenced.

Data Collection

Two student assistants were equipped with stacks of surveys and clipboards and sent to public spaces on the university campus. There were three versions of the survey, and student assistants were instructed to pass each one out in approximately the same number. They were also encouraged to obtain a representative sample of the campus student population, which included purposeful targeting of African American students.

Survey Instrument

The three versions of the surveys were the same, with the exception of the final block of science career-related questions. In this block of questions, each survey included one geoscience field and biology, but the specific science fields were divided among three survey versions. One version asked students to comment on geography, engineering, and biology careers. Another version asked students to comment on meteorology, chemistry, and biology careers, and a third version asked students about geology, physics, and biology careers. Only biology was common among all the surveys. It was thought that asking students to respond to four questions for seven science fields would lead to fatigue and the possibility of acquiescence bias, so each respondent only responded to four questions about three fields. See the supplemental material, available in the online journal,[3] for a copy of the survey. All respondents were asked seven additional Likert-type questions about geoscience and biology majors, a word-association question about biology, meteorology, geography, and geology, and a series of questions about their interest and self-efficacy in STEM. They were also asked to check from a list of STEM fields whether they knew someone employed in that field. Questions also measured perceived importance of six career factors, agreement with seven reasons for the respondent's choice to take a specific science elective, and perceived importance of 11 factors in a respondent's choice of major. The respondents' background was characterized through questions on demographics, science and math classes they had taken, college major, and parent's level of education. Care was taken to balance

[3] Available at http:dx.doi.org/10.5408/15-112s1.

any questions about geosciences with similar questions about biology. It was never revealed to the respondents that faculty in a geoscience department were conducting the survey, although some may have recognized the student assistants who were passing out surveys as geoscience majors.

Many of the questions in the four-page survey were used in previous research on enhancing diversity in geoscience or other STEM fields (e.g., Whitney et al., 2005; Kind et al., 2007). Others were taken or modified from a geosciences item database, assembled for the National Science Foundation by the American Institutes for Research and provided to one of the authors on a compact disc at a meeting for grantees of projects targeted at enhancing diversity in the geosciences (AIR, 2011). Geoscience graduate and undergraduate students provided feedback on the surveys before they were used in the field. For questions that measured similar attitudes toward different subject areas, a reliability analysis was conducted using a Cronbach α–value of 0.60 as a threshold to determine whether all questions about "geoscience" or "biology," for example, could be combined into an index value. The results of this analysis for geoscience and biology career knowledge and career perception questions for each of the sciences indicated subjects should not be grouped. Therefore, each individual question was treated separately in further statistical analysis.

Student Population

A total of 645 students responded to the survey, with slightly fewer providing answers to demographic questions. Students of all majors were targeted for two reasons: to be able to compare STEM majors with non-STEM majors, and to be able determine why students in any major chose their specific science electives. Of the approximately 630 students who gave their race, 71.5% identified as white, 21.3% as black, 2.9% as Asian, 1% as Hispanic, 3% as other, and 0.3% as Native American. This compares very favorably to the demographic statistics of the university student population, which in 2014 was 71.5% white, 20.7% black, 2.2% Hispanic, 1.2% Asian, 0.6% Native American or Pacific Islander, and 3.8% other categories. Because of the distinction made in the study between minority and underrepresented minority students, those identifying as "other" were not included in URM/nonminority comparisons. Just over half of the respondents were male (50.2%), and 49.8% were female. Males also represent slightly more than half of the university population (51.8%). The average age of respondents was 20.6 y (SD $=$ 2.94), and the average number of semesters completed was 4.5 (SD $=$ 5.18). The highest level of education obtained by respondents' mother and father was most frequently college graduation (38.6% of mothers and 34.7% of fathers). When URM and nonminority (including white and Asian) students were examined separately, their mother's level of education remained very similar: 33.3% of URM students' mothers had graduated college. However, only 23.3% of URM students' fathers graduated college. The most frequent response for URM students' fathers' education was high school graduation (31.8%). For nonminority students, 40.6% of their mothers and 38.7% of their fathers had graduated college. More than 80% of nonminority students completed Algebra 1 (89.3%) and 2 (88.4%) and Geometry (85.9%) in high school, and 37.5% had completed Calculus. Fewer URM students completed each of these math classes, with 72.5% completing Algebra 1, 73.2% completing Algebra 2, 65.5% completing Geometry, and 24.6% completing Calculus. Both level of parents' education and level of math classes completed in high school have been associated with persistence in a STEM major (Chen and Soldner, 2013). However, parents' level of education is not a consistent predictor (e.g., Hossler and Stage, 1992; Hurtado et al., 1997; Dennis et al., 2005).

Statistical Analysis

Responses to each question were explored through descriptive statistics, such as mean, range, and standard deviation (where a Likert-type scale was used), or frequencies for categorical data. Additionally, Kolmogorov-Smirnov tests were run to test the assumption of normality in the data. Because of lack of normality, a nonparametric Mann-Whitney *U*-test for difference of ranks was used to compare URM and nonminority responses. Where comparing responses between STEM subjects for a given respondent, a Wilcoxon matched-pair test was used. For the groups of questions about selection of a college major and perception of geoscience and biology majors, exploratory factor analysis was performed to determine whether responses tended to group in a way that could be explained by differences in subject area or reasons suggested in the literature.

RESULTS

Selection of College Major and Science Electives

First, students were asked to indicate how much they agree (on a 5-point Likert scale) with each statement about the effect of various factors in their *selection of college major*.

Statements appear in Table I. The selection criterion with the highest level of support was a strong interest in the major before coming to university (scoring 4.14 out of 5), followed by the perception that the major would help them find a job (4.08). Two criteria scored just above the midpoint of the scale: the prestige of the major (3.33) and knowing someone with a career in the major field (3.04). All the other factors fell below the midpoint on the level of their effect. Guidance counselors played the least-important role, according to respondents (1.82). When responses were compared between URM and nonminority students, significant differences were found in the effect of the guidance counselor, the ability of the major to help them find a job, the prestige of the major, and knowing what a person wanted to do since they were a child. Each of these differences was significant at $p \leq 0.05$.

A factor analysis with Varimax rotation indicated that these selection criteria were spread among three distinct factor components (Table II). The first factor can be described as *important influencers* (parents, guidance counselors, teachers, and department). The second factor indicated a *sustained identification with or interest in that major* (strong interest before coming to university, knowing the subject they wanted to major in since they were young, and knowing someone in that field). The final factor can be described as *descriptors of the major* itself and included helping them to find a job and being prestigious. The presence of facilities for their major and the fact that the major was not too difficult loaded about equally on the first and third factors. In the unrotated component matrix,

TABLE I: Likert-scale responses for the factor "selection of college major" among undergraduate students. Significant differences in the responses between URM and nonminority students are indicated with asterisks.

Influencing Factor	Average Agreement (SD)	URM Response	Nonminority Response
My parents played a big role in which major I chose	2.84 (1.29)	2.83 (1.37)	2.85 (1.25)
My high-school guidance counselor helped me to decide what major to select	1.82 (0.90)	2.02 (1.08)*	1.76 (0.85)
My choice of major was influenced by a teacher in high school or middle school	2.65 (1.29)	2.67 (1.37)	2.65 (1.28)
I chose my major based on the facilities of that department at university	2.83 (1.19)	2.81 (1.28)	2.83 (1.17)
I thought my major would help me find a job	4.08 (0.93)	4.22 (0.90)*	4.06 (0.92)
I had a strong interest in my major subject before coming to university	4.14 (0.97)	4.23 (0.99)	4.12 (0.96)
I chose my major because I thought it would not be too difficult	2.19 (1.07)	2.23 (1.20)	2.17 (1.03)
I chose my major because it was prestigious	3.33 (1.08)	3.53 (1.05)**	3.26 (1.09)
Someone in that department encouraged me to major in that subject	2.55 (1.15)	2.59 (1.24)	2.54 (1.12)
I knew what I wanted to do with my life since I was a young child	2.80 (1.37)	3.11 (1.34)**	2.71 (1.39)
I knew someone growing up who had a career in my major subject	3.04 (1.39)	3.06 (1.42)	3.01 (1.40)

*Significant at $p < 0.001$.
**Significant at $p = 0.01$.

facilities grouped more distinctly with the influencer category, whereas the difficulty grouped with the characteristics of the major itself.

The next set of questions delved into a bit more detail on *why students chose the particular science electives they chose*. Because one of the primary ways students enter geoscience majors is through introductory classes (Hoisch and Bowie, 2010), it is important to see what leads students to those classes in the first place. In addition to what science classes they had already taken, students were asked whether they expected to have taken at least one geoscience class before graduation. Of all the students, 38.8% expected to have completed at least one geoscience course, with nearly 30% not sure. The percentage was greater for nonminority students. For URM students, 34.2% expected to complete a geoscience course, whereas the percentage was 40.9% for nonminority students. A set of seven Likert-type statements probed why students chose the particular science classes they did. The statement that generated the greatest level of agreement was that a student's advisor had told him or her exactly which science class to take (3.47 out of 5). This was followed by the material in the science class sounding interesting (3.06). Taking the course because parents helped the respondent choose it or to be in the same class with friends had the lowest levels of agreement (1.86 and 2.30). Because they thought the class would be easy (2.73), because

TABLE II: Factor analysis results showing loadings of the responses on each of three components. The three factors explained 43.8% of the total variance. Bolded numbers highlight the factors loading strongly on each component.

Influencing Factor	Important Influencers	Identification/Interest	Descriptors of Major
Parent's role	**0.57**	0.31	0.03
Guidance counselor's help	**0.69**	0.11	0.02
Teacher's influence	**0.52**	0.05	0.12
Department's encouragement	**0.56**	−0.21	0.21
Strong precollege interest	−0.03	**0.56**	0.28
Knew since a child	−0.05	**0.78**	−0.07
Knew someone with that career	0.19	**0.67**	−0.04
Would help them find job	0.01	0.06	**0.75**
Major was prestigious	0.17	0.04	**0.67**
Facilities of university or department	0.37	−0.11	0.48
Major not too difficult	0.38	−0.18	−0.35
Percentage of variance explained (%)	15.70	14.40	13.65

TABLE III: Frequency of responses to the question "do you know anyone personally who is employed in the following fields?" among undergraduate students.

Not Counting the Professors or Teaching Assistants Who Have Instructed Your Classes, Do You Know Anyone Personally Who Is Employed in the Following Fields?	Percentage Answering "Yes"	URM Students	Nonminority Students
Engineering	40.6	34.8	42.4
Biology	25.2	26.2	25.8
Chemistry	21.2	22.0	21.7
Meteorology	12.7	7.8	14.4
Physics	12.5	7.1	14.4
Geology	7.8	2.1	9.2
Geography	5.5	5.0	5.4
Ocean science	4.4	2.1	4.3

the instructor had a good reputation (2.92), and because the class had a seat available (2.71) rated close to the middle of the scale. The only reason that led to a significant difference between URM and nonminority students was to be in the same class as a friend ($p = 0.01$). In this case, nonminority respondents expressed greater agreement with that statement.

Students were also asked whether they knew anyone in the various science fields, not counting the professors or teaching assistants they had in classes (Table III). Students knew more engineers than they did people in any other field (40.6%). Biology was second, followed closely by chemistry. The geoscience fields all fell below these more familiar subjects. Meteorology, however, was selected slightly higher than physics. In each of the geoscience fields, more nonminority students knew someone employed in them than URM students did. The reverse was true with the two life sciences, biology and chemistry.

Students were also asked a series of questions to assess their *interest in and self-efficacy in science and math*. Students were most in agreement with an overall statement of self-efficacy: "*If I do well in college, I will be able to get a good job*." URM students responded to this statement with a greater level of agreement than nonminority students did (4.45 versus 4.20). This difference was significant ($p < 0.01$). Students also expressed a high level of agreement with the statement that they have a friend who was a science major (4.01 out of 5). The lowest levels of agreement were three negatively phrased statements about science and math. There was significant difference between URM and nonminority students to two of these statements: "*Science is boring*" ($p < 0.01$) and "*My grades in my science classes are lower than my other university required* [courses]" ($p = 0.03$). URM students expressed more agreement with each of those statements (Table IV).

Career Perceptions Within Geoscience Subfields and Between Geoscience and Other Stem Fields

Students also responded to a set of Likert-type statements regarding *how important each of several factors is in describing their ideal career*. Helping people and society was the highest-rated factor in an ideal career, followed by helping the environment. Interestingly, URM students and nonminority students differed significantly ($p < 0.05$) in their rating of every factor. In all but one factor, URM ratings were higher. The one factor that nonminority students rated higher was the importance of working outdoors. This was the only factor in which URM students tended toward disagreement (Table V).

Students were also asked to state their agreement with seven statements about geosciences and biology *careers or majors* (Table VI). Responses fell very close to neutral, with

TABLE IV: Likert-scale responses for the factor describing "self efficacy in STEM and college" among undergraduate students. Significant differences in the response between URM and nonminority students are indicated with asterisks.

STEM Statement	Average Agreement (SD)	URM Response (SD)	Nonminority Response (SD)
If I do well in college, I will be able to get a good job	4.25 (0.77)	4.45 (0.72)***	4.20 (0.77)
One or more of my friends is in a science major	4.01 (1.01)	3.99 (1.14)	4.03 (0.96)
I enjoy my math classes	3.10 (1.42)	3.16 (1.50)	3.10 (1.39)
Science is one of my favorite subjects	3.06 (1.41)	2.91 (1.46)	3.12 (1.39)
Math is hard for me	2.74 (1.32)	2.72 (1.40)	2.72 (1.28)
Science is boring	2.61 (1.21)	2.86 (1.28)**	2.52 (1.16)
My grades in my science classes are lower than my other university requirements	2.40 (1.09)	2.58 (1.17)*	2.33 (1.05)

*Significant at $p < 0.05$.
**Significant at $p = 0.01$.
***Significant at $p < 0.001$.

TABLE V: Likert-scale responses for the factor describing "how important each of several factors is in describing their ideal career" among undergraduate students. Significant differences in the response between URM and nonminority students are indicated with asterisks.

Career Factor	Average Agreement (SD)	URM Response (SD)	Nonminority Response (SD)
Helping people and society is important	4.54 (0.59)	4.67 (0.53)**	4.51 (0.59)
Helping the environment is important	4.17 (0.81)	4.39 (0.65)***	4.09 (0.83)
Making a lot of money is important	3.56 (1.17)	3.98 (1.13)***	3.42 (1.15)
Having prestige is important	3.55 (1.09)	3.91 (0.97)***	3.44 (1.10)
Working outdoors is important	3.13 (1.14)	2.8 (1.22)***	3.24 (1.09)
Working in an office is important	2.82 (1.08)	3.16 (1.23)***	2.72 (1.00)

**Significant at $p = 0.01$.
***Significant at $p < 0.001$.

the greatest level of agreement with the statement that "*a biology major would be difficult*" (3.51). The lowest level of agreement (2.22) was with the statement "*I know what classes you would have to take with a major in geosciences*." There was a large difference in responses to similar questions about biology and geosciences. For example, the average response to the statement "*I know what classes you would have to take with a major in biology*" was more than a full point higher (3.32). Similarly, the average response to "*I have a good idea of what careers exist for a geoscience major*" was 2.67, whereas the same question about biology careers was 3.37. Students agreed that both majors would be difficult, but to a higher level with the biology major (3.51 versus 3.32 for the difficulty of the geoscience major). An exploratory factor analysis indicated that responses clustered more on factors describing the *perceived difficulty* of both majors and the *knowledge of the two majors* or careers than on factors that would account for differences between geoscience and biology. Differences between each of the pairs of similar questions discussed above were significant at $p < 0.001$. Responses to only one of the statements was significantly different between URM and nonminority students ($p = 0.009$). This statement was that "*a major in geosciences requires too many math classes*," which was not asked about biology majors. URM students expressed a higher level of agreement with that statement than nonminority students did (3.04 versus 2.85). In retrospect, this question should also have been asked about biology. However, we do not believe that its inclusion would have significantly changed the results.

The final set of questions about science asked students the same four questions about careers in three *different STEM fields*. Each student responded to statements about biology, one geoscience subfield, and one additional science field. The data in Fig. 1 show the perceptions students had about each career. A career in biology was seen as the best able to help the environment (4.0 out of 5), with physics scoring the lowest (3.36). Biology was also rated most able to help society (4.06), with physics scoring lowest (3.50). Students believed it would be most easy to find a job in engineering (3.84), with geography scoring lowest at 2.84. All of the geoscience fields scored low in this category. Geology's average rating for ability to find a job was 2.85, and meteorology was not much higher at 2.92. All were below 3, which indicate a tendency toward disagreement with the statement. Engineering was also perceived as being most amenable to making a lot of money (4.07), with geography scoring lowest (2.94).

TABLE VI: Likert-scale responses for the factor describing "perceptions about geoscience and biology majors/careers" among undergraduate students. Significant differences in the response between URM and nonminority students are indicated with asterisks.

Geoscience or Biology Statement	Average Agreement (SD)	URM Response (SD)	Nonminority Response (SD)
A biology major would be difficult.	3.51 (1.05)	3.44 (1.15	3.52 (1.030
A geoscience major would be difficult.	3.32 (0.89)	3.36 (0.97)	3.31 (0.88)
I have a good idea of what careers exist for a biology major	3.37 (1.10)	3.47 (1.15)	3.37 (1.08)
I know what classes you would have to take with a major in biology	3.22 (1.21)	3.38 (1.28)	3.18 (1.19)
A major in geosciences requires too many math classes	2.92 (0.87)	3.04 (0.80)**	2.85 (0.85)
I have a good idea of what careers exist for a geoscience major	2.67 (1.02)	2.69 (1.14)	2.67 (0.98)
I know what classes you would have to take with a major in geosciences.	2.22 (1.21)	2.30 (1.20)	2.20 (1.09)

**Significant at $p = 0.01$.

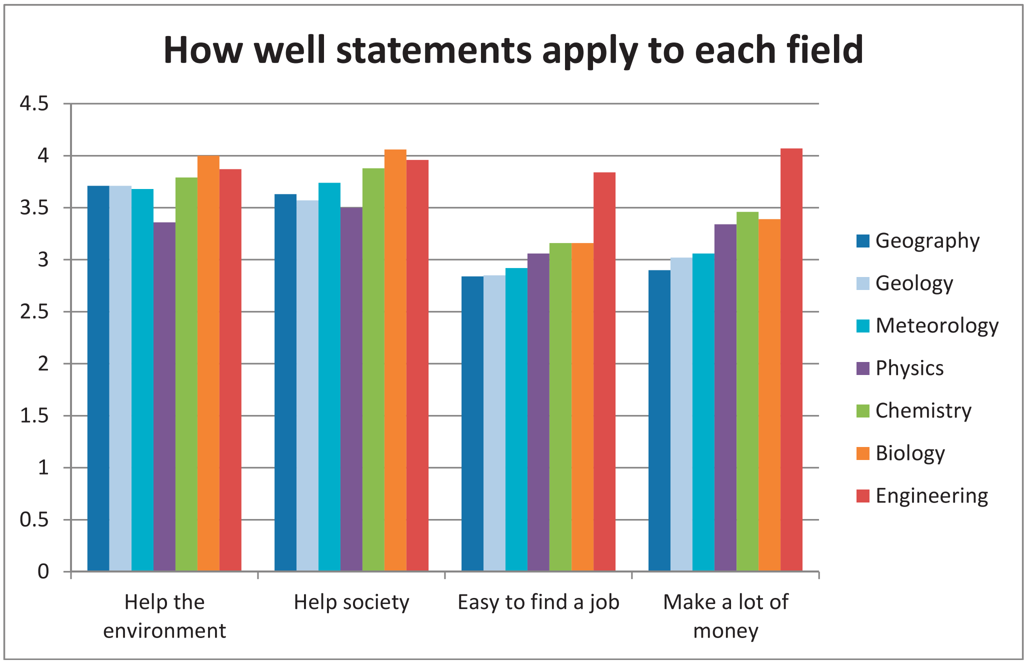

FIGURE 1: How well each STEM field and geoscience subfield is perceived at meeting these career characteristics (the STEM and geoscience subfields listed in the legend apply left to right for each career characteristic).

Not every STEM subject could be compared with every other STEM subject across respondents because a respondent saw only three of the science fields. Table VII displays the results of paired *t*-tests for each of the science fields that could be compared. Many of the comparisons were significant, so it may be more effective to note which comparisons were not significant. Fewer significant differences were found between physics and biology or between chemistry and biology with respect to money and ease in finding a job. Biology was close to engineering with respect to helping the environment and society. Although biology was perceived to be significantly better able to help the environment, the difference between biology and engineering was smaller than it was for other fields. Meteorology and chemistry were also perceived to help the environment at a similar level, and geology and physics were perceived to help society at a similar level.

DISCUSSION AND CONCLUSIONS

Positive undergraduate experiences, love of the outdoors, family influences, and, to a lesser extent, K–12 teachers or experiences have been attributed by geoscientists as important to pursuing and obtaining a geoscience degree (Holmes and O'Connell, 2003); however, among underrepresented students, these factors may have a completely different role than they do for white students (O'Connell and Holmes, 2011). Our results show several differences between URM and nonminority students' perceptions of the geosciences. We have examined these perceptions among

TABLE VII: Differences in agreement scores among subjects that can be compared. A negative score indicates the second subject in the pair was rated higher.

Paired Tests	Careers Help the Environment	Careers Help Society	Make Good Money	[Not] Hard to Find a Job
Geology–physics	0.39***	0.07	−0.32***	−0.21**
Geology–biology	−0.24***	−0.43***	−0.35***	−0.24**
Physics–biology	−0.63***	−0.50***	−0.02	−0.02
Meteorology–chemistry	−0.10	0.14*	−0.40***	−0.23**
Meteorology–biology	−0.37***	−0.25***	−0.41***	−0.22**
Chemistry–biology	−0.26***	−0.11*	0.01	0.03
Geography–engineering	−0.17*	−0.33***	−1.17***	−1.00***
Geography–biology	−0.30***	−0.35***	−0.47***	−0.41***
Engineering–biology	−0.13*	−0.01	0.68***	0.61***

*Significant at $p < 0.05$.
**Significant at $p = 0.01$.
***Significant at $p < 0.001$.

five subsets of questions to understand the factors influencing students in (1) the selection of college major, (2) the selection of science electives, (3) characteristics of the ideal career, (4) interest in and self-efficacy in science and math, and (5) career perceptions of geoscience and other select sciences.

Exposure is a key element in attracting students to the geosciences. Our results showed that a strong interest in the major before coming to university was the highest-ranked factor for the selection of a college major, followed by the perception that the major would help them find a job. Additionally, the prestige of the field was a significant factor in previous research (Hoisch and Bowie, 2010) and in this research. Salary and prestige contributed to students' choice in major, and they tended to rate geologists lowest in salary and least prestigious (Hoisch and Bowie, 2010). Our research supports this conclusion in which the geosciences did not score as high as most other science subjects in ability to find a job and salary. This is despite the 2014 median annual wages for geoscientists (not counting hydrologists or geographers) being about $30,000 higher than life, physical, and social science occupations (Bureau of Labor Statistics, 2016), pointing toward either lack of information or misinformation among students about the geosciences. In our study, the geosciences were also perceived as less able to help society and the environment. Our results were true not only for geosciences collectively but also for each of the individual geoscience subfields. The only other STEM field that scored lower than the geosciences in helping society and the environment was physics. The results showing that the geosciences were not perceived as offering as much opportunity to help the environment or society as biology, chemistry, and engineering had may be surprising to individuals with careers in the geosciences, but not when the lack of exposure for students to those careers is considered. *Recommendation:* Based on our results, opportunities associated with the geosciences to help society and the environment should be communicated to students early—long before they attend college, and with a clear connection to a job.

The environment in which the geosciences are perceived to occur is also a factor of consideration for students. African American males and females were less likely to endorse outdoor items on an occupational inventory than were white, Hispanic, or Native American females and males (Fouad and Walker, 2005). Hoisch and Bowie (2010) showed a correlation with working outdoors, enjoying observing nature, and enjoying outdoor activities with the selection of a geology major among the largely nonminority population surveyed. Our research confirms findings from these studies and further demonstrates that outdoor-related factors are not as positively viewed by URM students and, therefore, would not be the most-effective recruitment tool to the geosciences for these populations. This points toward the need to educate students about the various pathways that can be studied in the geosciences that do not necessarily include field work components—e.g., laboratory work, computation, and modeling, geographical information systems, data analysis, and so on. *Recommendation:* When recruiting a broader swath of the public to include minority students to the geosciences, faculty typically tend to highlight their international travels and field work; however, we should keep in mind that not all populations will have the same motivations for joining the field that we had as students, and we should provide equal time in our recruitment efforts on the laboratory and technological skills the field has to offer.

Students' high level of agreement in our study that their advisor told them exactly which science classes to take (agreement of 3.47 out of 5) calls attention to the importance of academic advisors. Students also picked a course based on whether it sounded interesting (agreement 3.06 out of 5), and URM students tended to rate higher the factors of helping society and the environment for an ideal career as compared with nonminority students. This aligns with previous research that found correlations among respondents' choice of major and the perception that it would lead to environmentally friendly employment (Hoisch and Bowie, 2010). These factors may be considered together to help departments with recruitment. *Recommendation:* Our results suggest that there may be a need for professional development among faculty/college advisors because they are a main controller for science (and geoscience) course enrollment. Although most university advisors will be in fields other than geosciences with an interest in keeping students in those fields—professional development can even help geoscience faculty make better connections for the students between their science classes and opportunities associated with geoscience careers. Because it is likely that the inaccurate career perceptions and lack of the knowledge about the geosciences is persistent in both STEM and non-STEM fields, as well as at different levels of education, geoscience departments should offer advisory information for anyone who might use it. This includes university advisors and also high-school guidance counselors, who our results indicated had more influence on URM student decisions about majors than they do for nonminority students. Furthermore, the geoscience course descriptions (and courses themselves) that are submitted for students to make choices from could be rewritten to be more appealing to diverse groups of students. Attributes that we have measured to be of interest to URM students (e.g., careers with prestige, office careers, applications and relevancy to society, helping the environment, etc.) should be considered. Better course titles may be another way to generate interest in a geoscience elective.

Another finding from our research is that URM students tended to have higher self-efficacy concerning the correlation between degree achievement and job placement but lower scores in their attitude about science and their own ability to be successful in science than their nonminority counterparts had. Respondents agreed that if they work hard and do well they believe they will get a job. However, at the same time, they reported lower grades in science than in other courses and tended to think a major in the geosciences required too many math classes. *Recommendation:* In this case, it is important to educate students and faculty advisors about the different fields of the geosciences and how the math requirements differ depending on the field chosen, where some fields (e.g., environmental geology) tend to have lower math requirements than other fields do (e.g., atmospheric sciences).

Finally, our work found that when the geosciences are included in a student perceptions survey in which several nongeoscience fields are also listed, the geosciences were most often rated lower in student responses, indicating that the geosciences was generally less likely to be chosen as a field of study by students. Also, within the geosciences, meteorology tends to be perceived slightly more favorably (e.g., that is easiest to find a job, makes the most money, and helps society), closely followed by geology and geography. This may reflect the amount of exposure students receive about each field. Although high-school courses are limited in all three fields, meteorology is easily "seen" on television and other media outlets.

Overall, from our findings, we recommend to geoscience programs that are serious about increasing their diversity to start on campus (especially those campuses that already have a diverse student population) and find ways to educate university faculty advisors and current students early in their career about the field. Geoscience elective courses and information used to recruit students into those courses should address career pathways, salaries, workforce needs, and highlight technological aspects of the geosciences and opportunities in the laboratory, as well as make evident how the field contributes to society and the environment. Actions to complete this recommendation could include volunteering to present information about the geosciences at on-campus, faculty professional-development workshops, to include elements that might be attractive to diverse populations (e.g., talking about how laboratory work is key to your research) when invited to give on-campus research seminars to different departments, and to be ready to share information about your program with a brochure that addresses some of the misinformation areas found in this research (e.g., salaries, job opportunities, ability to help other people and the environment, etc.). Finally, it is important to be visible with readily accessible information on a department Web page, a flyer in a student cafeteria, and, probably most effectively, having a slide show ready for departmental student organizations to disseminate such information to peer groups. Additionally, faculty teaching introductory courses that include higher numbers of nonmajors and minority students should keep these factors in mind when designing their course descriptions and materials and during their teaching practice. For instance, pausing during a lecture to show salary statistics in the field, discussing how the field helps people and society, or clarifying the amount of math one needs to take to major in the different geoscience areas may be worthwhile in attracting diversity to the field. Additionally, working with local community colleges and high schools to disseminate information to teachers, guidance counselors, and students would assist in increasing the knowledge about the field as well as correcting any misinformation. Of course, this all takes time and effort, and as such, departments should invest resources on recruitment efforts, including purchasing or designating personnel time or taking advantage of existing on-campus professionals that can assist in the information campaign.

The current study included some limitations. It was completed on one campus with a sample of convenience, which may limit the transferability of our results to other settings. However, the surveyed population was very close to the larger demographic representation of the university, and it was a relatively large sample ($N = 645$), which adds robustness to our study results. Our recommendation for future work in this area is to conduct a survey of university faculty and academic advisors to understand whether some of the misinformation or lack of information students receive about the geosciences can, in fact, be attributed to their advisors.

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