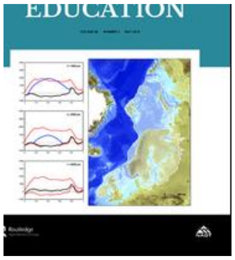

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# Teachers' Geoscience Career Knowledge and Implications for Enhancing Diversity in the Geosciences

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Kathleen Sherman-Morris,[1,a] Michael E. Brown,[1] Jamie L. Dyer,[1] Karen S. McNeal,[1] and John C. Rodgers III[1]

## ABSTRACT

This study examines discrepancies between geoscience career knowledge and biology career knowledge among Mississippi science teachers. Principals and in-service teachers were also surveyed about their perception of geoscience careers and majors. Scores were higher for knowledge of what biologists do (at work) than about what geoscientists do. Career knowledge was enhanced by race, where African American teachers perceived higher biology career knowledge and lower geoscience career knowledge than other races; however, the difference was not significant. Teachers also rated their personal knowledge of 12 of the 2010 Earth and Space Science Content Strand topics. Perceived knowledge of geoscience concepts was significantly less than knowledge of more environmental topics. Race was not significant, but differences between the two topics were enhanced by race. Perceived knowledge of geoscience topics was also significantly lower among female educators across all ethnicities. Because of the lack of Earth science classes taught before college and the demonstrated gaps in geoscience career knowledge even among science teachers, strengthening geoscience career awareness as well as increasing geoscience content knowledge among science teachers would be useful overall, as well as in attempts to enhance diversity in the geosciences. © *2013 National Association of Geoscience Teachers*. [DOI: 10.5408/11-282.1]

*Key words*: diversity, geosciences, African-Americans, gender, career knowledge

## INTRODUCTION

The geosciences as a whole (e.g., Earth, atmospheric, and ocean sciences) have the lowest participation by members of underrepresented groups of all the science, technology, engineering, and math disciplines (Huntoon and Lane, 2007). According to the 2010 Science and Engineering Indicators, only 240 Bachelor's degrees in geosciences out of 73,835 science degrees, were awarded to members of underrepresented minorities in 2007 (NSB, 2010). Bachelor's degrees earned in biology have risen from 1995 to 2007, but geosciences degrees earned by all students fell from 4,478 in 1995 to 4,077 in 2007. Among minorities, degrees earned in both geosciences and biological sciences increased during the same period. For both African Americans and Hispanics, however, the increase was greater in the biological sciences than it was in the geosciences. This discrepancy is more pronounced among African Americans, for whom degrees earned in biological sciences increased by 81%, whereas degrees earned in geosciences only increased by 23%. Although the rate of increase among Hispanics earning degrees in geosciences is closer to the increase in those earning degrees in biological sciences, the latter science still has both a higher total and a greater rate of increase among this underrepresented group.

There are multiple reasons for the underrepresentation of minorities in geoscience majors and careers, including barriers to participation, but also lack of awareness of, and interest in, the geosciences (Levine et al., 2007). For various reasons, minorities may not develop an interest in the geosciences. A desire to work outdoors and an appreciation of nature have been linked with the pursuit of geoscience careers (Holmes and O'Connell, 2005; Levine et al., 2007), but Caucasians are more likely to report enjoying participation in outdoor activities (Whitney et al., 2005) and learning about nature (Quimby et al., 2007). Geoscience may also not be valued by the African American community because it is seen as not directly helping the community (Fields, 1998). High-ability, minority students who leave the sciences are generally more likely than their Caucasian counterparts to value making a contribution to society (Grandy, 1998). This perception of decreased societal contribution is one of the primary reasons biology is said to have a greater desirability among some minorities. African Americans are drawn to biology and then medicine because of the perceived impact they might have on their community (Baker, 2000). This idea is supported by data presented by Fadigan and Hammrich (2004), who interviewed and tracked participants in the Women in Natural Sciences program, a program for academically talented females from low-income and single-parent households, about what careers they desired. Among this group of primarily African Americans, the authors found that medical or health related careers were the greatest number of both desired and actual careers pursued. Among the sciences, biology was the highest, with very few physical sciences even mentioned by the participants.

A lack of awareness of the geosciences also results in part from the small number of geoscience graduates, which then leads to a decreased likelihood of students knowing anyone with a geoscience degree (Levine et al., 2009). Many are not familiar with what geoscientists do (Fields, 1998). This lack of awareness can contribute to a negative perception of the geosciences (O'Connell and Holmes, 2011). In a survey of undergraduates, geoscience majors

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and occupations were considered not very prestigious, which was linked with low salary expectations (Hoisch and Bowie, 2010). Without the awareness of geoscience careers, parents may push their children into fields they assume are more lucrative or into careers with which they are more familiar. Whitney et al. (2005) found that African American high school and college students perceived less family support for them to become a geoscientist. The lack of geoscientists, especially from underrepresented groups, also makes it less likely a student will find a geoscientist role model (Levine et al., 2009). Access to role models has been a demonstrated factor in explaining minority participation among multiple sciences (Grandy, 1998). Biological sciences are not immune to the lack of minority role models (Baker, 2000), but many students are familiar with individuals in medical or health professions before entering college.

Lack of awareness results not only from lack of role models but also from the lack of Earth science being taught in school before college. Most states in the United States do not require Earth science at the high-school level, so students are more likely to take biology or chemistry (Gonzales, 2009). For those students who take Earth and space science, it is the subject with the greatest number of teachers teaching out of their primary content field (Seastrom et al., 2002; Lewis and Baker, 2010). Teacher preparation is an issue that must be addressed to increase minority participation in the geosciences (Fields, 1998). Many programs have been offered for K–12 teachers with the ultimate goal of increasing minority participation in the geosciences through increasing their Earth science content knowledge or increasing their interest or awareness of geoscience majors or careers (Pecore et al., 2007; Sedlock and Metzger, 2007). Providing professional development for teachers that includes ready-to-use lessons is one way to encourage them to incorporate the Earth sciences in their classroom. Earth science is often taught at the middle or junior high-school level, and Earth science concepts can be incorporated into other sciences and still address state standards. The attitude of teachers toward a subject has also been shown to influence students' level of interest (Breen 1979), and enjoyment of science has been shown to be more important for persistence in science than are grades for at least one sample of minority students (Grandy, 1998). A related strategy to increase representation in the geosciences would be to improve the students' enjoyment of these classes.

Fadigan and Hammrich (2004) suggested that science teachers can encourage girls to pursue physical science careers by supporting their understanding that physical science careers and helping others are not mutually exclusive. This suggestion would seem to be valid for geoscience careers as well. However, because most science teachers do not having a content specialty in the Earth sciences and the general public lacks awareness of what geoscientists do (Fields, 1998), do science teachers have enough knowledge of geoscience careers and majors to provide this information to their students? The researchers in this study explored differences in knowledge about geoscience and biology careers among 5th–12th grade, in-service teachers who represent a diverse sample in the state of Mississippi. The guiding hypotheses were (1) race of the teacher plays a role in teacher familiarity with biology and geoscience careers, and (2) teacher-perceived knowledge of Earth and space science standards is influenced by race and content type (e.g., environmental versus physical geoscience topics). The most prominent minority race in Mississippi is African American, so the analyses discussed below will refer specifically to the differences between African Americans and Caucasians.

In addition, although female participation in the sciences has increased to the point where women are no longer considered underrepresented in a number of sciences, including the life sciences, the number of women obtaining geoscience degrees still lags behind the number of men (Huntoon and Lane, 2007). For this reason, the authors also chose to address whether gender influenced perceived knowledge of Earth and space science standards as well as familiarity with biology and geoscience careers.

## SURVEY METHODS

As part of a project funded to plan future professional development opportunities for science teachers, two surveys were administered to Mississippi, in-service, science teachers. The authors consulted a database of geoscience-related survey items evaluated by the American Institutes for Research, which was provided to the lead author, as well as literature on teacher professional development (e.g., Chval et al., 2008) and attitudes toward science measurement (Kind et al., 2007; Osborne, 2003) in creating the survey instruments. Some items were modified, and additional items were created, where necessary, to meet the specific goals of the study. Item writers in a concurrent project to enhance diversity in the geosciences as well as geoscience experts reviewed the items and were allowed to suggest changes that would improve the items for the respondents in this study. Questions on one of the surveys were intended to be used by both in-service teachers and their students. Therefore, readability was an issue we considered. A Flesch-Kincaid test of readability indicated that the relevant portions were written at a 4th–5th grade level. The research had multiple goals and was considered exploratory; therefore, most items were limited to a single question to limit the length of the survey and prevent fatigue by the participants.

The first survey was administered after human subjects research was approved by the researcher's institution in March 2010, when 750 surveys were mailed to Mississippi science teachers. The surveys were mailed to a proportionally representative sample of teachers from high schools (38.1%) and middle or junior high schools (61.9%) on a current practitioner list provided by the Mississippi State Department of Education. The mail survey received 185 responses, a response rate of 25%. The survey did not allow respondents from middle, junior, and high schools to be differentiated. The purpose of the mail survey was primarily to identify the type of professional-development experiences teachers would prefer. In addition to these questions, teachers were asked to comment on several statements relating to geoscience knowledge, including the statements "I know what geoscientists do" and "I have a good idea what majors exist for students interested in Earth and space science careers." To provide a comparison, teachers were also asked to agree or disagree with the statement "I know what biologists do." See Table I for examples of relevant questions.

**TABLE I: The mailed survey and workshop questionnaires and the primary goals of each survey as well as sample survey questions regarding perceived geoscience knowledge and self-reported understanding of biology versus geoscience careers.**

| Mail Survey | Workshop Survey |
|---|---|
| **Primary Goals** | |
| (1) To measure participants' perceived knowledge of the 2010 content strand topics in Earth science in preparation for a workshop about the new content strand framework and professional development opportunities related to them.<br>(2) To measure science teachers' understanding of geoscience and biology careers as part of a series of questions about teachers' comfort in science teaching and preference for different teaching methods | (1) To measure workshop attendee's perceived knowledge of the 2010 content strand topics in Earth science.<br>(2) To measure teachers' attitude toward the geosciences in a more comprehensive way than was intended in the mailed survey. The goal was to ask these questions in a way that could also be included on a subsequent survey of these teachers' grade 5–12 students. |
| **Sample Survey Questions** | |
| Perceived Knowledge of Content Strand Topics | |
| Both Surveys | |
| "The following topics are included in the new 2010 Mississippi State Science Standards Earth and space science content strands. How would you rate your personal knowledge of each topic?" (Response choices were "Excellent," "Very Good," "Good," "Satisfactory," and "Poor.") | |
| Relationship of Factors That Affect an Ecosystem | |
| Impact of human activities on the environment, conservation, and efforts to maintain/restore ecosystems. | |
| Theories pertaining to the history of the universe and concepts related to the interaction of celestial bodies. | |
| History and evolution of the Earth. | |
| Factors used to explain the geological history of Earth. | |
| Earth systems relating to weather and climate. | |
| Earth's position relative to objects in the universe. | |
| Plate tectonics and geochemical and ecological processes that affect Earth. | |
| Geographic information systems. | |
| Earth's structure, composition, and renewable and nonrenewable resources. | |
| Properties and structure of the sun and the moon with respect to the Earth. | |
| Connections among Earth's layers including the lithosphere, hydrosphere, and atmosphere. | |
| Understanding of Geoscience and Biology Careers | |
| (Questions were 5-point, Likert-type statements with responses "Agree Strongly," "Agree," "Neutral," "Disagree," and "Disagree Strongly") | (Questions were 5-point, Likert-type statements with responses "Agree Strongly," "Agree," "Neutral," "Disagree," and "Disagree Strongly") |
| "I know what biologists do" | "I know what classes you have to take to become a geoscientist" |
| "I know what geoscientists do" | "I don't know much about possible geoscience careers" |
| "I have a good idea what college majors exist for students interested in Earth and space science careers" | "I have a good idea of what geoscientists do at work" |

The second survey was conducted in July 2010, in conjunction with a planning workshop held for science teachers and administrators. The purpose of the workshop was to review the new statewide Earth and space science framework and to discuss future opportunities available at the university to improve science teachers' ability to teach Earth science. This workshop was attended by 36 teachers (including five teachers with the National Science Foundation [NSF]–sponsored Graduate K–12 (GK–12) Initiating New Science Partnerships in Rural Education (INSPIRE) program housed on the university campus), 11 principals, and 10 graduate students who were beginning a GK–12 INSPIRE fellowship. All but one workshop participant completed a survey for a 98% response rate. The second survey included more geoscience-specific questions, such as "A major in geosciences requires too many math classes" or "Most geoscientists make good money," but did not include a similar statement about biology.

Both surveys included a section about teachers' perceived personal knowledge about 12 strand topics on Earth and space science content included in the 2010 revised Mississippi State Science standards for grades 7–12. Participants in both surveys were asked to rate their knowledge of the 12 topics along a 5-point scale from poor to excellent. Both surveys also obtained demographic data about the teachers, including their content-area specialty, their race, their gender, and the racial makeup of the schools in which they teach (Table II). The respondents were overwhelmingly Caucasian or African American. Only 4 individuals identified themselves as another race (2 Asians, 1 Hispanic, and 1 "Other"). For that reason, we chose to restrict the analysis to Caucasians and African Americans only.

**TABLE II: Characteristics of the mail and workshop survey respondents.**

| Characteristic | Mail Sample | Workshop Sample |
|---|---|---|
| Number of responses | 185 | 56 |
| Percentage of teachers | 100 | 64.3 |
| Education (% of advanced degrees) | 56.8 | 57.1 |
| School with high minority enrollment ($\geq$85% minority enrollment; %) | 28.6 | 40.4 |
| Percentage of African Americans | 21.9 | 23.6 |
| Gender (% female) | 82 | 60.7 |

Because the response rate of the mail in survey was 25%, there is a possibility of a nonresponse bias. Workshop participants were a self-selected group that likely differed from the overall teacher population. However, although some of the analysis in this work included subgroup comparisons, significant results were identified through comparing pairs of survey responses for individual teachers (within-teacher responses) and the likelihood of finding different within-teacher patterns of response among respondents and nonrespondents was unlikely. However, caution in generalizing the study results outside of Mississippi teachers is needed because the survey has not been demonstrated to be reliable outside of that survey population (cultural validity). In addition, other validity issues, such as criterion validity (relating our survey results to an independent survey with Mississippi teachers), were not possible in this research. The researchers, however, have included and/or modified existing survey questions in the implemented surveys and used experts to review the survey, thereby achieving face and content validity.

## STATISTICAL METHODS

An undergraduate research assistant entered the data into an Excel spreadsheet (Microsoft Corporation, Redmond, WA), numbering the paper copies of the survey sequentially, and linking those numbers with the data so the two could be cross-referenced. One of the authors imported the data into SPSS, now called PASW (IBM Corporation, Armonk, NY), and used this program for the analysis. Data values were visually inspected for outliers that appeared to be misplaced and then compared with values on the paper copy of the survey. Once responses to each of the questions were examined, the statistical analysis focused on the two primary research goals of the study: to examine differences between biology and geoscience items across the sample and then to examine differences between African American participants and Caucasian participants, as well as gender differences, within each item about biology and geoscience. Initially, the hypothesis that science teachers have a better grasp of what biologists do than the grasp they have on what geoscientists do was tested with a Wilcoxon signed-rank difference test. Because responses to every item were not all normally distributed, nonparametric tests were run for all of the difference tests. The Wilcoxon signed-rank test is a nonparametric alternative to the matched-pairs *t*-test. Next, the race of the teacher was considered, and the hypothesis that African American participants may be less familiar than other races are with geoscience careers was tested with a Mann-Whitney *U*-test for independent samples. Similarly, the Mann-Whitney *U*-test is a nonparametric alternative to the Student's *t*-test. Tests were conducted on responses to three items about familiarity with geoscience careers between African American participants and other races. Each will be described below.

Next, because the average perceived knowledge on content topics among the 12 Mississippi Earth and space science framework appeared to show higher scores for items about the biosphere and lower scores for items about the lithosphere and atmosphere, an exploratory factor analysis was run to validate whether there were, in fact, two distinct concepts being measured. Once the factor analysis was complete, a reliability analysis was conducted on the two factors that emerged before they were analyzed any further. Finally, perceived knowledge of each of the two content factors was compared with each other and compared by both race and gender. For all of the statistical results discussed below, a result is considered significant when the probability that the test statistic could have occurred by chance was less than 5%.

## RESULTS AND DISCUSSION

Respondents to the mail survey expressed their agreement with two statements, "I know what geoscientists do" and "I know what biologists do." When the average responses were compared, a significant difference ($p < 0.0001$) was found between the two statements. On a 5-point Likert scale from "Disagree Strongly" (1) to "Agree Strongly" (5), respondents scored an average 4.02 regarding what biologists do, compared with only an average of 3.38 regarding what geoscientists do. Because of the differences discussed above between Caucasian and minority students about their awareness and perceived value from geoscience and biology careers, the authors also examined the race of the respondent as a factor in the respondents' knowledge of what geoscientists versus biologists do. Respondents who identified themselves as African American rated their belief that they know what geoscientists do lower than did Caucasians (3.18 versus 3.40). However, regarding expressed knowledge of what biologists do, African American respondents scored higher than Caucasian respondents did (4.15 versus 3.98) (Fig. 1). Neither comparison between African American and Caucasian respondents was statistically significant ($p > 0.05$). The authors explored possible differences further by comparing male and female responses to these questions. Although males rated their knowledge higher than females did for both questions, both males and females expressed a higher level of knowledge about what biologists do than they did about what geoscientists do (Fig. 2). The difference in perceived knowledge within each gender was also significant at $p \leq 0.001$.

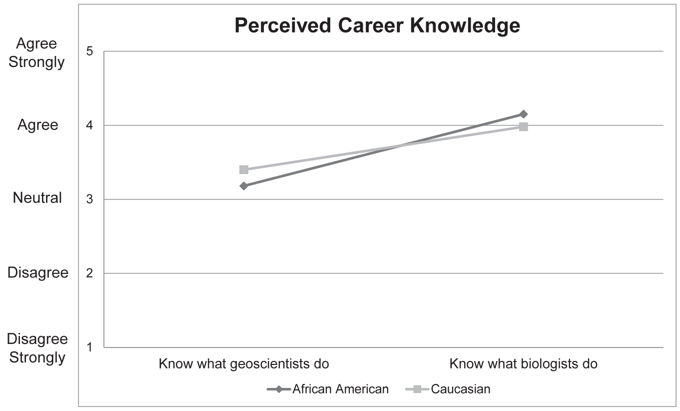


**FIGURE 1: Average agreement with the statements "I know what geoscientists do" and "I know what biologists do." Difference is significant ($p < 0.05$) between knowledge of geoscientists and biologists, but not between races.**

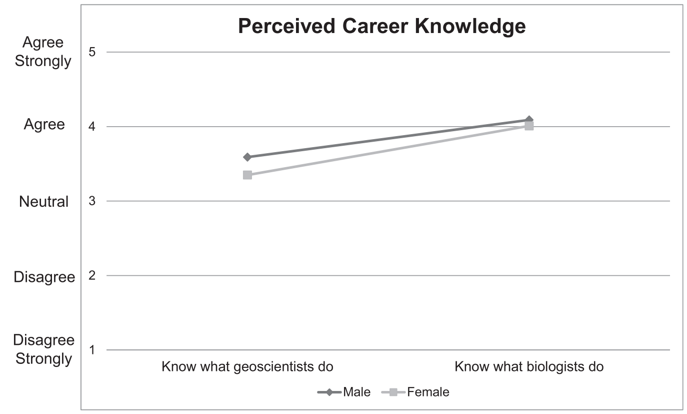


**FIGURE 2: Average agreement with the statements "I know what geoscientists do" and "I know what biologists do." Difference is significant ($p < 0.05$) between knowledge of geoscientists and biologists, but not between genders.**

The mail survey also asked respondents to express their agreement with the statement, "I have a good idea what majors exist for students interested in Earth and space science careers." Respondents were "neutral" about whether they knew what majors exist for students interested in Earth and space science careers. The average of the 183 responses was 3.09 out of 5. Once again, when comparing races, African American respondents rated their knowledge of geoscience majors as lower than Caucasian respondents did (3.03 versus 3.07), but the difference was too small to be statistically significant. The workshop survey asked respondents to agree or disagree with the following statement, "I know what classes you have to take to become a geoscientist." The wording was changed from the mail survey to correspond more closely with a survey planned for students in grades 5–12. Responses to this question indicated slight disagreement (average = 2.64). The lower rating may be the result of the workshop question being phrased more specifically, asking about classes instead of majors, or because a broader range of respondents were questioned (e.g., principals and graduate students). As with the previous questions, African Americans indicated greater disagreement with this statement than Caucasian participants did (2.23 versus 2.79). This difference was not significant ($p = 0.152$).

Participants in both survey groups were asked to rate their personal knowledge about 12 strand topics about Earth and space science content. Nine of the topics were more related to the Earth, its lithosphere, and its atmosphere. Two of the topics focused more on the biosphere, and one topic was on geographic information systems (GIS), which was the only topic that can be considered a technique as opposed to an applied science. Expressed knowledge of these topics ranged from an average 2.30 for GIS to 3.52 (out of 5) for impact of humans on the environment (Table III). The two highest rated topics were the biosphere topics (3.52 and 3.42).

A factor analysis was conducted on 11 of the content strand topics with the GIS topic removed to determine whether there were two (or more) separate concepts being measured—one more biological and one more physical. The factor analysis confirmed that there were two primary components based on an eigenvalue of 1 or greater that explain 69% of the total variance; therefore, these two factors were retained for analysis. The associated component matrix (Table III), which shows the correlations between the two principal components and the content strand topics, indicated that the primary component showed relatively high, positive loadings in all categories, whereas the secondary component showed only meaningful loadings for "Relationship in ecosystem" and "Impact of humans on the environment." Based on this result, the primary component analysis showed that there was a strong correlation between respondents' knowledge and all geoscience topics, such that the variability in the personal knowledge was more or less equal for all categories. This factor could be referred to as "overall geoscience knowledge" because the correlations were roughly equal. However, the secondary component analysis indicated that knowledge of content related to human relationships and impacts on the environment was most prevalent; therefore, this factor could be referred to as "environmental geoscience knowledge."

The responses to perceived knowledge of the content strand topics were divided to create two new variables called "Environmental Geoscience Knowledge" and "Geoscience Knowledge." The variables, even though they have been called geoscience or environmental "knowledge" do not measure knowledge per se. They are merely a measure of the confidence a respondent has in his or her mastery of that particular topic. The name "Environmental Geoscience" was chosen to reflect that the first two topics were not entirely distinct concepts. Because they comprise the environmental geoscience knowledge variable, responses about knowledge of the first two topics were not included in the geoscience knowledge variable. After the topics were combined into the new variables, a reliability analysis was performed. Environmental geoscience knowledge (topics 1–2) had a Cronbach $\alpha$ value of 0.892 and geoscience knowledge (topics 3–11) had an $\alpha$ value of 0.924, both of which indicate a high level of internal consistency. When each respondent's scores on the two variables were compared, the respondents rated their

**TABLE III: Average Likert-scale and principal-component loading scores on perceived knowledge of the content strands of Earth and space science. An average response is provided for geographic information systems, but that topic was not included in the factor analysis.[1]**

| Question | Average Response | Loading Values, Geoscience Knowledge | Loading Values, Environmental-Geoscience Knowledge |
|---|---|---|---|
| (1) Relationships in the ecosystem | 3.42 | 0.648 | 0.683 |
| (2) Impact of humans on the environment | 3.52 | 0.676 | 0.649 |
| (3) History of the universe | 2.70 | 0.740 | −0.279 |
| (4) History and evolution of Earth | 2.83 | 0.722 | −0.141 |
| (5) Geological history of Earth | 2.58 | 0.805 | −0.182 |
| (6) Weather and climate systems | 2.90 | 0.731 | −0.176 |
| (7) Earth's position in the universe | 3.18 | 0.754 | −0.204 |
| (8) Plate tectonics | 2.81 | 0.842 | −0.044 |
| (9) Earth's structure, composition, and resources | 3.29 | 0.825 | 0.190 |
| (10) Sun/Moon/Earth relationships | 3.00 | 0.788 | −0.245 |
| (11) Connections among the spheres | 2.90 | 0.830 | −0.084 |
| (12) Geographic information systems | 2.30 | N/A | N/A |

[1]N/A = not analyzed.

knowledge of environmental geoscience topics significantly higher (3.47 out of 5) than they rated their geoscience knowledge (2.90) ($p < 0.001$).

Once the new variables were created, they were used for further analysis. We began by examining possible relationships among knowledge of what geoscientists do, what biologists do, and these two new variables. The strongest correlation was between perceived environmental-geoscience knowledge and perceived geoscience knowledge (Table IV). Expressed knowledge of what biologists do was positively correlated with expressed knowledge of what geoscientists do, as well as perceived environmental-geoscience knowledge and perceived geoscience knowledge. Expressed knowledge of what geoscientists do was also positively correlated with both perceived geoscience and environmental-geoscience knowledge. It was not surprising that these variables were correlated. What was interesting was that the correlation was stronger between knowledge of what biologists do and environmental knowledge and between what geoscientists do and geoscience knowledge. The lowest correlation was found between geoscience knowledge and knowledge of what biologists do. All Spearman correlations below were significant at $p < 0.01$.

Perceived geoscience knowledge and perceived environmental-geoscience knowledge were also examined for differences between races and genders. There were no significant differences in perceived environmental-geoscience knowledge or in perceived geoscience knowledge between African American respondents and Caucasian respondents (see Fig. 3). There was a significant difference between male and female respondents in their perceived geoscience knowledge (3.22 versus 2.85, $p = 0.01$) (Fig. 4). A higher percentage of male teachers in the sample declared an Earth science content area specialty, but the difference remained significant when those respondents were removed. There was no difference between males and females in the perceived environmental knowledge.

## CONCLUSION

The literature indicates the geosciences have suffered from a lack of awareness and misperception by students about what it is and what a geoscience career might be like. Fewer minorities enroll and graduate in the geosciences than they do in other science, technology, engineering, and mathematics (STEM) majors, and therefore, there are fewer minority role models to promote the geosciences. Much of the effort to increase K–12 student knowledge of geoscience careers and majors, therefore, falls on K–12 teachers. Because of that, it is important to evaluate teacher knowledge of geoscience content, as well as careers and majors. This research has shown that, in Mississippi, even among science teachers, perceived knowledge of geoscience careers is lower than is perceived knowledge of biology careers. The difference between African American respondents and other respondents was not significant, thus, it is

**TABLE IV: Correlation values among expressed career knowledge and perceived content knowledge responses. All correlations are significant at $p < 0.01$.**

| Question | Know What Biologists Do | Know What Geoscientists Do | Environmental-Geoscience Knowledge | Geoscience Knowledge |
|---|---|---|---|---|
| Know what biologists do | 1 | | | |
| Know what geoscientists do | 0.447 | 1 | | |
| Environmental geoscience knowledge | 0.499 | 0.286 | 1 | |
| Geoscience knowledge | 0.238 | 0.373 | 0.567 | 1 |

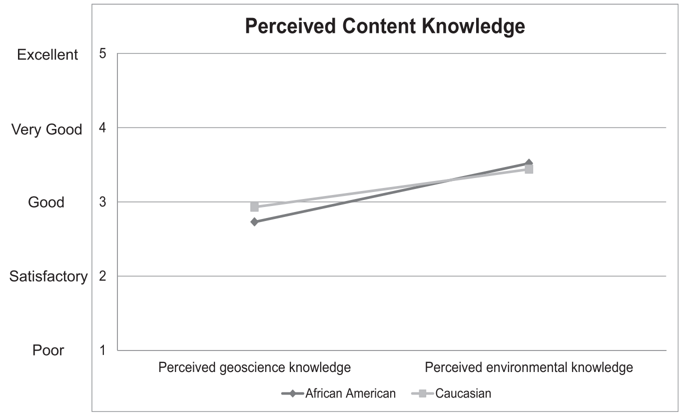


**FIGURE 3: Perceived knowledge of geoscience content strand topics and environmental geoscience content strand topics. Difference is significant ($p < 0.05$) between geoscience and environmental knowledge, but not between races.**

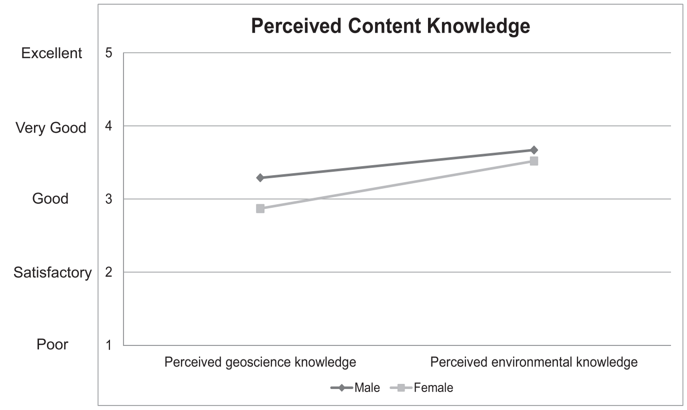


**FIGURE 4: Perceived knowledge of strand topics on geoscience content and environmental-geoscience content strand topics between male and female respondents. Difference is significant ($p < 0.05$) between geoscience and environmental knowledge and between males and females in geoscience knowledge.**

likely that teachers, in general, have much less knowledge about geosciences than they do about biological sciences, regardless of their race. If teachers perceive their knowledge of geoscience content to be weaker than their knowledge of other subjects, they may not teach it as effectively as they teach those subjects with which they are more comfortable (Westerback and Long, 1990; Zacharia, 2003). In addition, if teachers have less knowledge of geoscience careers to begin with, as suggested by this study, it follows that they may have difficulty incorporating examples of those careers into their classes. Biology already has an advantage over geosciences because a greater number of students take biology courses before college. As such, any opportunity to expose students to the geosciences should be taken.

Future outreach with teachers should provide opportunities for teachers to become more aware of the pathways toward a geoscience major or career. By teaching about the Earth sciences in a way that engages students and increases their interest, K–12 teachers can be important in efforts to encourage minority participation in the geosciences. Undoubtedly, all teachers need more exposure to geosciences; it is especially important for teachers that directly engage with minority and underrepresented populations to possess geoscience-career knowledge, so they can help transform the diversity shortcomings of the geosciences. Furthermore, it may be important that African American teachers specifically have this geoscience knowledge because they may be the most positively received role models for African American students. As such, future research should explore what students know about and how they perceive the geosciences and associated careers, the role of the messenger–teacher in providing geoscience career information to students, and the link between teacher and student knowledge of the geosciences.

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