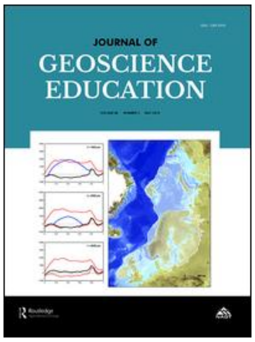

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Looking in the Right Places: Minority-Serving Institutions as Sources of Diverse Earth Science Learners

John R. McDaris,[1,a] Cathryn A. Manduca,[1] Ellen R. Iverson,[1] and Cailin Huyck Orr[1]

ABSTRACT

Despite gains over the last decade, the geoscience student population in the United States today continues to lag other science, technology, engineering, and mathematics disciplines in terms of diversity. Minority-serving institutions (MSIs) can play an important role in efforts to broaden underrepresented student engagement with Earth Science content, especially in collaborations with other institutions and organizations that allow MSIs to share their expertise. Knowing which MSIs have Earth-related degree programs can help facilitate such collaboration. This commentary describes an effort to find and raise the visibility of these programs. In 2013, the abundance of geoscience departments at MSIs was roughly half that seen in U.S. higher-education institutions. Yet we found that nearly a third of MSIs offered one or more Earth-related degree programs. In addition, more than half of the academic units offering Earth-related degrees were interdisciplinary rather than traditional geoscience departments. It is clear that students are learning about the Earth in a wider variety of places than geology programs. These programs could provide models for supporting diverse students in the geosciences, as well as sites for potential collaborations aimed at further increasing the diversity of the geoscience workforce. © *2017 National Association of Geoscience Teachers*. [DOI: 10.5408/16-224.1]

Key words: broadening participation, inclusivity, diversity

INTRODUCTION

The geoscience student population in the United States today remains the least diverse of any science, technology, engineering, and mathematics (STEM) field (Czujko and Henley, 2003; Mosher et al., 2014; Wilson, 2014). In addition to a basic inequity of opportunity, this poses a barrier to educating sufficient numbers of students in the geosciences to meet future U.S. workforce needs (Velasco and Velasco, 2010). It also makes it more difficult for the geoscience community to support diverse communities with research and expertise. To be a trusted partner, the geoscience workforce must include scientists from all the parts of society.

Diversity has many facets, but from a racial or ethnic perspective, the demographic trends are clear. By 2050, the U.S. will be a majority minority country (Colby and Ortman, 2015). Over time, an increasing number of students of color will enter college who could enroll in science, technology, engineering, and mathematics (STEM) courses. Making STEM in general, and geoscience in particular, more welcoming to, and supportive of, students from diverse backgrounds will be necessary to maintain and grow Earth-related degree programs (e.g., environmental science, water resource management, or mineral engineering) and the geoscience workforce. Meeting this challenge can yield important benefits for STEM departments as diverse students and graduates bring new perspectives and ideas (Wiltham et al., 2015). Finding these students, and fostering their interest in the geosciences, is the subject of much effort (Riggs and Alexander, 2007; National Research Council [NRC], 2013; Tewksbury et al., 2013). Our ability to be successful in meeting this challenge will have implications for the geoscience education community, as well as the workforce, for decades to come.

Despite recognizing the need for greater diversity in geoscience fields, we argue that the geoscience education community adheres to an overly narrow view of Earth-related education pathways. The main goal of this commentary is to shine a light more broadly on relevant degree programs found at minority-serving institutions (MSIs) and the potential for collaborations to increase diversity in the geoscience workforce. This commentary begins with a description of the basic demographics of geoscience graduates, contrasts these with the student demographics at MSIs, and thus highlights the important position MSIs play in educating a diverse STEM workforce. We then review information about Earth-related programs at MSIs gleaned from institutional websites and the opportunities for potential collaboration and learning that this information affords. Finally, we review some factors understood in the literature to influence underrepresented minority (URM) student persistence in STEM and make the case for further research into both how MSIs support their students programmatically and how knowledge of those activities could be deployed at non-MSIs to support minority students in STEM.

DEMOGRAPHICS OF GEOSCIENCE GRADUATES

Between 2002 and 2012, undergraduate college enrollment increased by 24%, from 16.6 million to 20.6 million (National Center for Education Statistics [NCES], 2016b). Embedded in that increase, enrollment of URM students increased almost 58%. This represents a growing percentage of the total undergraduate college enrollment. Over that same

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TABLE I: Demographic changes in college enrollment and STEM degree attainment, 2002–2012 for URM students. Data from NSF and NCSES (2015) and NCES (2016b).

	Students 2002	Students 2012	Increase 2002–12
College enrollment	16.6 M[1]	20.6 M	24%
URM	3.4 M (20%)	5.4 M (26%)	59%
All BS degrees	1.3 M	1.8 M	38%
URM	215,556 (17%)	360,310 (21%)	67%
STEM BS degrees	415,983	589,330	42%
URM	67,483 (16%)	111,240 (19%)	64%
Geoscience BS degrees	3,984	5,865	47%
URM	224 (5.6%)	489 (8.3%)	118%

[1]M = million.

decade, the URM share of geoscience Bachelor of Sciences (BS) degrees went up by 54%. However, the actual number of students remains small, accounting for only 8.3% of geoscience BS graduates in 2012 (489 out 5,865 graduates). In that same year across all STEM, 19% of bachelor's degrees went to URM students, and these groups made up 30% of the U.S. population overall (NSF and NCSES, 2015; NCES, 2016b). Table I provides additional detail on these demographic changes. While there has been progress and the growth trends are clear in Figs. 1 and 2, the number of minority geoscience graduates is not moving to parity as fast as overall college enrollment. This is a lost opportunity for all departments seeking to attract more students to their degrees and to grow their program overall. However, this pattern does not play out evenly across all institution types. There are lessons to be learned from the patterns.

IMPORTANCE OF MSIS

MSIs enroll a significant percentage of the total minority college student population in the U.S. Statistics from 2007 show that historically black colleges and universities (HBCUs) enrolled more than 10% of African American students. Hispanic-serving institutions (HSIs) enrolled nearly half of all Latino and Latina students. Tribal colleges and universities (TCUs) enrolled just over 7% of American Indian and Native Alaskan students (Aud et al., 2010). Institutions in these categories enroll only a small fraction of all students in higher education in the U.S. (HBCU, 1.7%; HSI, 13.4%; TCU, 0.1%) but they are serving a higher concentration of URM students. As a result, MSI programs have a special opportunity to introduce URM students to the geosciences.

MSIs have been successful in supporting students to completion of STEM degrees. At HSIs, being of Hispanic ethnicity does not decrease the likelihood of declaring a major in STEM but rather increases it (Crisp et al., 2009). HBCUs (just 3% of U.S. higher-education institutions) generated nearly 10% of all black STEM doctoral degree recipients (Upton and Tanenbaum, 2014). In addition, while previous research across all institutions found that URM students have a higher chance of leaving STEM majors if

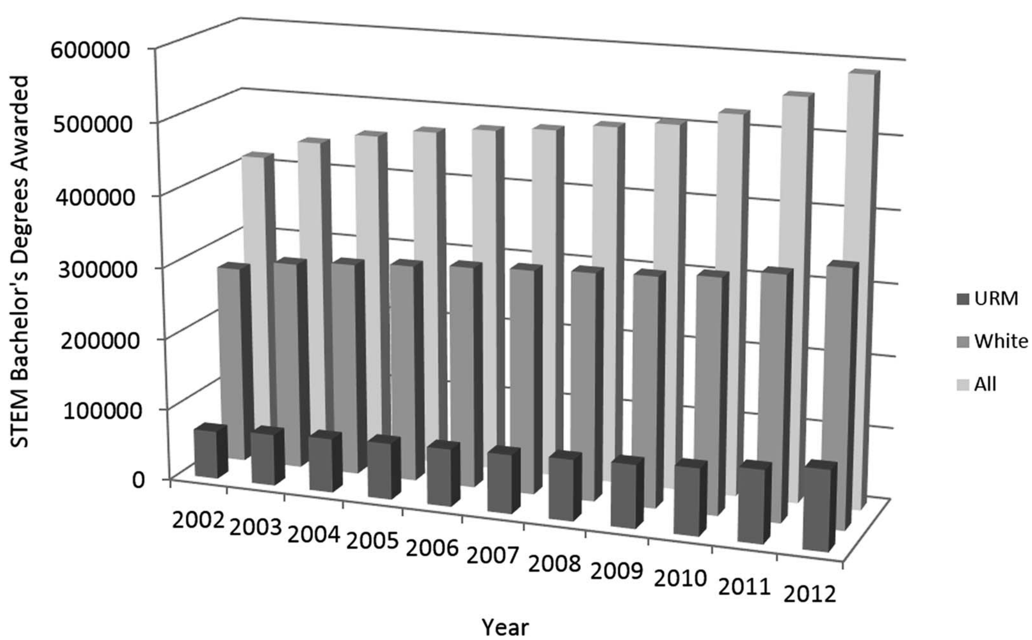

FIGURE 1: STEM bachelor's degrees awarded between 2002 and 2012 broken out by URM, white, and all recipients. (Data from NSF and NCSES, 2015.)

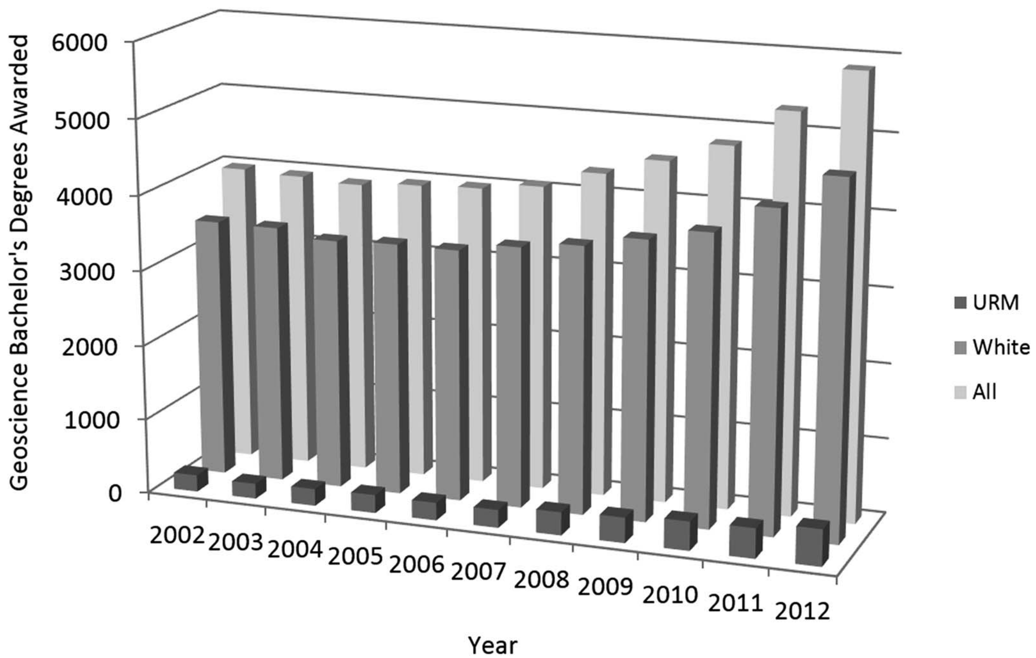

FIGURE 2: Bachelor's degrees in Earth, Atmospheric, and Ocean Sciences awarded between 2002 and 2012 broken out by URM, white, and all recipients. (Data from NSF and NCSES, 2015.)

they attend a more selective institution, this finding does not appear to hold true for HBCUs (Chang et al., 2008). For HBCUs, persistence increases with increasing selectivity. As the authors of the Chang et al. (2008) study state, "Given the unique mission of HBCUs to identify and nurture overlooked academic talent, it is not surprising that having a larger proportion of high-achieving students who are working toward a common goal operates differently at those institutions and tends to decrease rather than increase the risk of departure in the biomedical and behavioral sciences" (453). These insights suggest that MSIs are already making significant contributions to broadening the diversity of STEM disciplines.

A growing number of collaborations between MSIs and non-MSI institutions enhance the strengths of an MSI with expertise and resources from outside partners. For example, the Oceanography program at Savannah State University has longstanding collaborations with several research entities within the state of Georgia to provide research opportunities and support for the transition to graduate school to their students. The development of these relationships was the result of the history of this program but could be replicated at other institutions (Gilligan et al., 2007). The National Oceanic and Atmospheric Administration (NOAA) has made efforts for several decades to work with HBCUs to increase the number of URM scientists in NOAA-related disciplines through undergraduate scholarships, graduate training, and experiential learning and research opportunities (Robinson et al., 2007). Fisk and Vanderbilt universities have developed a reciprocal agreement to help URM students to matriculate from master's to Ph.D. programs and provide mentoring and additional interventions to support the programs' students and increase graduation rates (Stassun et al., 2010). These and other models showcase the variety of collaborations that can be developed to build on MSI successes in attracting and supporting URM students through graduation.

Making broader use of this partnership model requires information on Earth-related degree programs or pathways at MSIs. Without a clear understanding of the geoscience landscape at MSIs, it is difficult to determine how new collaborations should be designed and fostered. Some MSIs are included in the American Geosciences Institute's (AGI's) Directory of Geoscience Departments, which publishes self-reported information from institutions that have geoscience departments (AGI, 2013). However, departments that do not self-identify as geoscience yet offer Earth-related degree programs (those requiring significant learning about the Earth—e.g., Paleontology, Petroleum Engineering, and Environmental Sustainability) may not be represented in the directory. This leaves a gap in our understanding of opportunities for students to learn about the Earth and prepare for geoscience jobs or advanced degrees at MSIs.

WEBSITE REVIEW

To address the gap in knowledge, we conducted a systematic review of MSI websites to identify institutions offering undergraduate Earth-related degree programs. Three types of MSIs were the foci of this information gathering: HBCUs, HSIs, and TCUs. These three were chosen because (1) they represent a significant fraction of the total population of MSIs and (2) the lists of schools in each category were readily available from the U.S. Department of Education (U.S. ED, 2013). Using these lists, we searched the institutions' websites (e.g., registrar's office or course catalogs), as well as departmental websites (e.g., degree plans), for information on degrees that included geoscience coursework. We also determined the department or academic unit that housed these programs.

TABLE II: Distribution of Earth-related undergraduate degree programs discovered during the systematic website review displayed by degree title and degree program type.

Degree Title	AA[1]	AS[1]	AAS[1]	AST[1]	BA[1]	BS	Minor/Cert[1]	Unknown
Soil Science						1		
Paleontology	1							
Earth and Environmental Science						1		
Civil and Environmental Engineering						1		
Mineral Engineering						1	1	
Environmental Sustainability					1	1		
Environmental Geology						2		
Marine Science						3		
Geophysics						3		
Oil and Gas Technology/Petroleum Engineering			3			1		
Oceanography	4	1						
Natural and Physical Sciences		2	2	1				
Hydrology and Water Resources		1	1			3		
Earth System Science		1				4		
Earth and Planetary Science		1			2	2		
Atmospheric Science and Meteorology	1		1			3	1	
Environmental Engineering						9	1	
Earth Science/Geoscience Education					3	6	1	
Earth Science	1	4			2	5	2	
Geology/Geoscience/Geological Science	16	25		8	7	29	3	2
Environmental Science	7	23	4	1	7	48	6	3

[1]AA = Associate of Arts; AS = Associate of Science; AAS = Associate of Applied Science; AST = Associate in Science for Transfer; BA = Bachelor of Arts; Cert = certificate.

In 2013, there were 499 institutions officially recognized as an HBCU, an HSI, or a TCU. Institution websites were searched for information on degrees that required significant learning about the Earth as part of their program. Many of these programs were not labeled as Geology or Geoscience yet required students to take several courses focused on physical aspects of the Earth system and their interactions. For example, Paleontology, Marine Science, and Petroleum Engineering degree programs were included in the list of Earth-related programs. As an illustration, Environmental Studies degrees commonly had a biological focus, with little geoscience content, while Environmental Science degrees more often reflected a balance between the biological and physical systems. This led us to exclude Environmental Studies from the list of Earth-related programs while including Environmental Science. When complete information on degree program requirements or course content was not available, we chose to err on the side of inclusion.

Earth-Related Degree Programs Found

Of the 499 schools reviewed, 149 (30%) offered one or more Earth-related degree programs, with a total of 274 degree programs offered in 155 academic units (departments, schools, divisions, etc.) (see Supplemental Material, available in the online journal and at <http://dx.doi.org/10.5408/16-224.s1>). Broken out by type of MSI, 17% of HBCUs (18/105; 29 programs), 32% of HSIs (119/362; 223 programs), and 38% of TCUs (12/32; 22 programs) listed such degrees in their online materials. Geoscience and Environmental Science were the most prevalent programs represented on the institutions websites, but many other degrees were also discovered (Table II). Many programs appear more focused on a particular aspect of the Earth system (e.g., Marine Science, Soil Science, or Meteorology) or on developing specialized skills in graduates (e.g., Oil and Gas Technology) than on providing a broad exploration of geoscience. Still, these programs represent learning about the Earth and constitute pathways into the geoscience workforce.

Academic Units Offering Earth-Related Degree Programs

At those institutions with Earth-related degree programs, we found that 59 (12%) of the academic units (e.g., departments, divisions, and schools) offering those degrees were broadly disciplinary in nature and had names like Geology, Environmental Science, or Geography and Geology (Fig. 3). Physics, Biology, or Engineering departments also offered a small number of Earth-related degrees. However, 81 of the degree-granting academic units were interdisciplinary, with names that would include large swaths of disciplinary content, such as Natural Science, Science and Geography, Life and Physical Sciences, and Agriculture and Environmental Science (Fig. 4). By this count, more than half (62%) of the departments offering Earth-related degrees across all MSIs we looked at were not

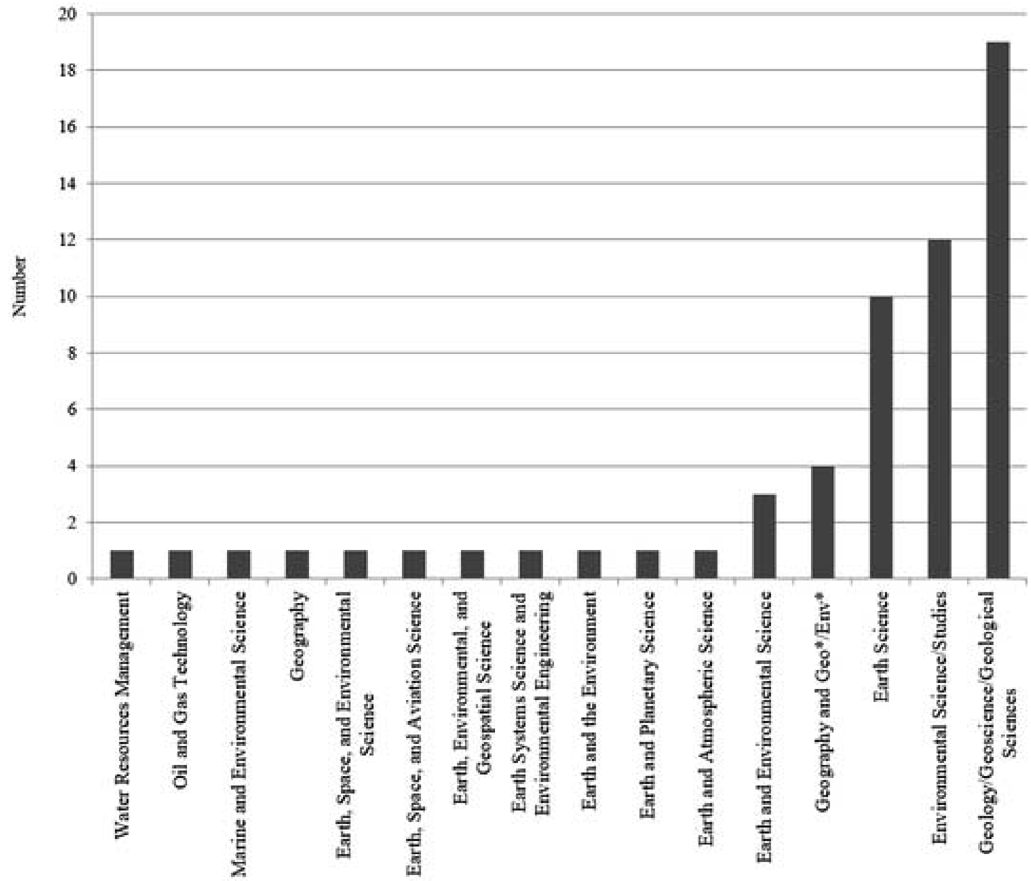

FIGURE 3: Distribution of the names of geoscience and environmental science academic units offering Earth-related degree programs discovered during the systematic website review.

traditional geoscience departments. Interdisciplinary departments were also responsible for most degrees offered, with 150 of the 274 total degrees (55%) located in these academic units.

The kinds of departments offering Earth-related degrees varied across the three types of MSIs. At HBCUs, none of the identified degree programs were offered in departments named Earth Science, Geoscience, or Geology. Broadly disciplinary departments (e.g., Environmental Science and Studies, Marine and Environmental Sciences, School of the Environment, and Water Resource Management) offered five (17%) of the programs, with the rest offering in cognate science (Physics) or interdisciplinary units. Of the 22 programs offered at TCUs, we found a single Environmental Science department offering 1 (5%) program, with the rest offered through interdisciplinary units. Among HSIs, however, 54 (45%) of the 119 academic units had names like Earth Science, Geological Sciences, or Environmental Science. In addition, at HSIs, these disciplinary departments offered nearly half (48%) of the Earth-related degree programs. In sum, HSIs are different from HBCUs and TCUs in that the former have a higher proportion of traditional geoscience departments offering Earth-related degrees, while the latter have higher proportions of interdisciplinary departments doing so.

A comparison to non-MSI institutions can provide some context for these numbers. In the 2011–2012 academic year, there were 4,706 undergraduate degree-granting institutions in the U.S. (NCES, 2016a). The corresponding AGI (2013) directory only lists 1,046 geoscience departments. That means that only 22% of U.S. degree-granting institutions reported having a geoscience department. As mentioned earlier, we found 12% of the departments offering Earth-related degrees at MSIs were geoscience departments. This is a small number, even compared to the low abundance of geoscience departments in general. If one is measuring Earth-related degree programs by the looking for geoscience departments, it is understandable that MSIs could be overlooked. However, as we showed above, the presence or absence of a geoscience department is not a good proxy for the presence or absence of Earth-related degree programs.

DISCUSSION

Prevalence of Earth-Related Degree Programs

Before starting the review of institutional websites, we knew of Earth-related degree programs at some institutions without departments named Geology or Environmental Science but did not anticipate the relative abundance of Earth-related programs that existed under other names. More than half of the identified programs at MSIs are offered outside of geoscience programs, indicating that there are many more opportunities to learn about the Earth than a count of geoscience programs would suggest. The diversity of degree programs in which Earth-related content was

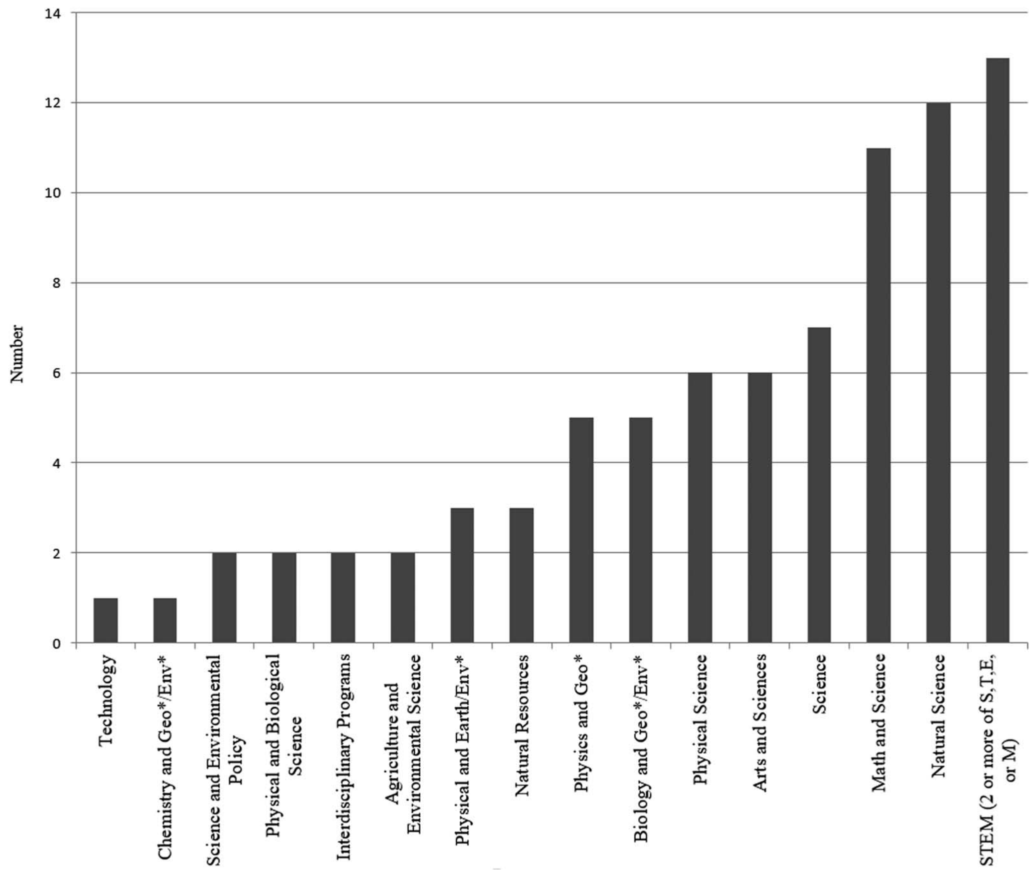

FIGURE 4: Distribution of the names of interdisciplinary academic units offering Earth-related degree programs discovered during the systematic website review.

taught was also broader than we had expected. It is likely that an investigation of non-MSIs would illuminate similarly "hidden" programs in which students are learning about the Earth outside geoscience departments.

Factors Affecting URM Student Persistence in STEM

There is agreement on an array of factors that help determine URM students' persistence in STEM degree programs and possible interventions or programs that can be employed to increase persistence. Here, we summarize current literature as a basis for interpreting the success of MSI programs to increase persistence.

The work of increasing URM student persistence starts before students enter college. Precollege academic preparation and engagement with STEM lead to increased confidence and self-efficacy during the undergraduate years (Packard and Nguyen, 2003; Markowitz, 2004; Chubin et al., 2005; Huntoon and Lane, 2007; Laursen et al., 2007; Pandya et al., 2007; Serpa et al., 2007; National Academy of Sciences [NAS] et al., 2011; Packard, 2012). Support for critical transitions, including those from high school to higher education, 2- to 4-y college, and undergraduate to graduate school reduces the number of students who do not persist. Increased persistence is the result of factors such as a sense of belonging in the discipline and a shared vision for the future (Chubin et al., 2005; Townsend and Wilson, 2006; Huntoon and Lane, 2007; Dowd, 2011; NAS et al., 2011; Suarez, 2011; NRC and National Academy of Engineering [NAE], 2012).

Once students are on campus, several factors related to the department and/or campus culture, atmosphere, and sense of belonging influence students' decisions to persist through graduation (Matsui et al., 2003; Anderman and Leake, 2005; Carter, 2006; Freeman et al., 2007; Hernandez and Lopez, 2007; Hurtado et al., 2007b, 2009; NAS et al., 2011; Strayhorn, 2012; Gross et al., 2015). URM students enter college with more interest in STEM degrees than their non-URM peers but face more early obstacles to their success than their peers (Oseguera et al., 2006). Academic and social support structures, including cultural centers, can contribute to building a sense of community that leads to longer student retention. Successful models for support include cocurricular programs such as STEM clubs, peer mentoring, and curricular programs such as undergraduate research experiences (Jackson et al., 2003; Nutt, 2003; Walsh, 2003; Sickles, 2004; Alan and Eby, 2007; Glenn, 2007; Hernandez and Lopez, 2007; Huntoon and Lane, 2007; Johnson, 2007; Pandya et al., 2007; Chang et al., 2008; Guillory and Wolverton, 2008; Hatton et al., 2009; Velasco and Velasco, 2010; Harding, 2012; Gross et al., 2015).

Student perception of a STEM discipline's relevance (or of STEM as relevant) to their lives and communities increases student motivation to persist in the discipline and overcome barriers to degree completion (Eyler and Giles, 1999; Johnson, 2002; Semken, 2005; Hurtado et al., 2007b; Guillory and Wolverton, 2008; Thoman et al., 2015). In addition, students are more likely to persist in STEM when they receive clear information about their career prospects in their chosen STEM discipline and career paths seem relevant and achievable for them (Sneider and Spears, 2002; Huntoon and Lane, 2007; Museus et al., 2011; O'Connell and Holmes, 2011). Understanding of possible career paths can come via opportunities for self-directed research and exploration, opportunities that by themselves lead to increased retention (Nagda et al., 1998; Ishiyama, 2002; Lopatto, 2007; Hurtado et al., 2007a, 2009).

Not surprisingly, financial support for tuition that reduces outside work commitment increases students' grades and persistence, including progress toward a degree (Tinto, 1993; Nora, 2001; Espinoza, 2004; Carter, 2006; Oseguera et al., 2006; Creighton, 2007; Hernandez and Lopez, 2007; Hurtado et al., 2007b; Guillory and Wolverton, 2008). Family support, both financial and emotional, also plays a large role in student success. When family expectations and responsibilities compete or conflict with school responsibilities, they may undermine student success. This is especially true for first-generation college students whose families may not have experience in supporting college students (Ginorio and Huston, 2001; Jackson et al., 2003; Guillory and Wolverton, 2008). For geoscience fields in particular, students often enter school with lower interest in or less experience with outdoor activities because of their family history (Whitney et al., 2005; Papadogiannaki et al., 2008; Taylor et al., 2011). Families' may have neutral or negative perceptions of the prestige and/or pay of geoscience careers (Hoisch and Bowie, 2010; O'Connell and Holmes, 2011; Stokes et al., 2014) or a lack of familiarity with the geosciences due to a widespread lack of high school geoscience courses (Blank and Langesen, 2005; Levine et al., 2007; Hoisch and Bowie, 2010).

These known factors are unlikely to be a comprehensive list, and they will interact in a diverse set of ways for specific students and institutions. A more detailed understanding of how MSI programs attract, support, and teach their students could underpin adaptation of successful practices across higher education, including the large percentage of non-MSI schools that lack geoscience programs. Being able to compare practices between MSIs and non-MSIs could highlight differences in student outcomes and allow a deeper understanding of both specific strategies and institutional context. This would strengthen our ability to broaden minority participation in geoscience at any institution.

CONCLUSIONS

The identification of heretofore unrecognized sites of geoscience learning opens up opportunities for learning and collaboration. With nearly a third of MSIs offering one or more Earth-related undergraduate degree programs, it would be valuable to understand where and how these students are entering the geoscience workforce and what type of partnerships or interactions among institutions of higher education or with professional societies could strengthen these pathways. Such collaborations and partnerships, building on the strengths of MSI institutions in serving URM students, would increase capacity for meeting future workforce and diversity goals.

Students are learning about the Earth in a wider variety of places than geology programs. Students at MSIs have more opportunities to learn about the Earth than previously recognized. This has implications for faculty interested in geoscience education research, as well as those seeking to broaden participation. Just as "geoscience" encompasses a multiplicity of fields, "geoscience student" should include those gaining geoscience expertise, regardless of the name of the degree program. Without including the experiences of all students learning about the Earth, we can't effectively research important geoscience education questions any more than we can address grand global challenges without an understanding of all aspects of the Earth system and how they interact. Identifying the full range of Earth-related learning opportunities is the first step in ensuring that geoscience education research addresses the experiences of all students.

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