Title: Accounts and Recommendations for Recruitment of Under-Represented Groups in the Geoscience STEM Discipline

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ABSTRACT

The authors seek to amplify their voices as scholars of color in the presentation of a case study of recent geoscience higher education data in the University System of Maryland. We explore trends in geoscience graduate rates and describe the context with national, state, and local data. This paper also includes position statements and lived experiences from faculty of color who recruit in the geosciences. Three women of color share collective intersectional experiences as

STEM majors in undergraduate and graduate programs, public and private institutions, HBCUs and PWIs. The aim is to offer recommendations to enhance the literature on diversity and recruitment in geoscience and advance opportunities for students seeking degrees in the geosciences.

Keywords

STEM education, diversity, recruitment, retention, geoscience

WOMEN IN GEOSCIENCE BACKGROUND

As scientists, we strive to provide data-driven conclusions to answer our world's most pressing research questions to provide solutions that invoke a positive, needed change. The method by which we recruit and retain underrepresented groups in the geoscience STEM (Science Technology Engineering Mathematics) discipline requires one to look beyond the data and into the narrative (i.e., ontological objects), (Feig & Stokes, 2011) and viewpoint presented as evidence to make an informed change or recommendation. Great efforts have been made to address the inequities and inequalities women face as it relates to career advancement and marginality in the geoscience field (Hastings, 2021; Holmes et al., 2015; Ranganathan et al., 2021). In addition, efforts have been made to offer solutions and strategies to advance the culture of inclusivity for underrepresented groups and women in geoscience (Christensen, n.d.; Hernandez et al., 2020; Medicine et al., 2020). The geoscience field has shown modifications in its practices to improve retention and recruitment efforts of underrepresented groups(Asher et al., 2019; Bhattacharyya & University of Wisconsin-Whitewater, 2016; McNeal et al., 2021; Wolfe

& Riggs, 2017). The improvements for recruitment and retention are admirable, but the cultural (Berhe & Ghezzehei, 2021) and structural barriers of academia still exist (Berhe et al., 2022; Bernard and Cooperdock, 2018).

The introduction of a science or STEM field topics requires background knowledge to show topic inception and current applications. This practice, too, can be explored to highlight the importance of underserved and underrepresented groups (e.g., women) in geoscience and STEM. The first step is exposure to those who have come before and laid a foundation in STEM fields (https://www.youtube.com/watch?v=T5196ZW9s-g; https://obamawhitehouse.archives.gov/women-in-stem), addressing where they are now in STEM (https://www.higheredtoday.org/2015/03/03/where-are-the-women-in-stem/; Hill et al., 2010; Stokes et al., 2014), and how might we increase their representation in STEM. Therefore, in this paper, we intend to explore trends in geoscience graduation degrees in the last five years within the University System of Maryland (USM). Furthermore, we will highlight the measures taken by faculty of color to retain students who identify as non-white in the STEM subdiscipline of geoscience. Specifically, using statistical data from enrollment at the USM schools and discussion of the lived experiences of three faculty women of color within the USM present a case study and framework to advance gender, racial, and ethnically diverse students towards graduate degree completion in the geosciences. Collectively, this commentary answers the following research questions: 1. How can faculty recruit under-represented and underserved minorities into Geosciences? 2. What are the barriers to recruitment for under-represented and underserved minorities in science/engineering? and 3. What are the lived experiences of STEM [research and education] faculty in higher education?

INTRODUCTION and CONTEXT

Since the turn of the century, the number of racial/ethnic groups identifying as minority increased their numbers in enrollment and graduation rates in relation to baccalaureate, master, and doctorate degrees earned (Beane et al., 2021; National Center for Education Statistics [NCES], 2019). The statistics reported herein were collected from NCES, Department of Education; Census Bureau, Department of Commerce; and Bureau of Labor Statistics, and Department of Labor. Specifically, Figure 1 shows the NCES data from 2000-2016 of the total college enrollment rate for students who identified as Black, Hispanic, Pacific Islanders, and American Indian/Alaska Natives. During this same period, data shows the number of Hispanic and Black students enrolled in postbaccalaureate programs more than doubled enrollment. A minimal increase was also observed for Pacific Islander and Native American/Alaska Natives over the 2000-2016 reporting period. The data for doctorate degrees awarded also show an overall increase for Hispanic, Black, and Asian/Pacific Islanders, respectively. A decrease was observed for American Indians/Alaska Native groups. In 2016, females were awarded more baccalaureate degrees, overall, than males (58% vs. 42%), but in STEM fields males received more baccalaureate degrees than females (36% vs. 64%).

The aforementioned reported statistics indicate students who identify as Black or Hispanic are choosing to pursue higher education in the form of baccalaureate, master, and doctoral degrees. The 100-fold increase is an indication that the measures taken at the PK-12 level of education are valuable and have a measurable impact (Miles and Terrell Shockley, 2018; Rivera & Li, 2020). The increase in enrollment is likely a reflection of early exposure to higher education through experiential learning (Atwater et al., 1999; Kampe and Oppliger, 2011; Lent et al., 1994; Margot & Kettler, 2019), encouragement of PK-12 counselors and teachers (Terrell Shockley and Krakaur, 2020;

Schwartz et al., 2016; Zeng et al. 2020), and exposure to national/international impacts of geoscience fields helping society and the environment (Sherman-Morris et al., 2016). Although this data is promising, the Native American ethnic group, underserved communities, participating women and persons with disabilities are still disproportionately low and recognized as severely underrepresented groups (https://www.nsf.gov/od/oia/activities/ceose/reports/2019-2021-ceose-biennial-report-508.pdf). Therefore, it is critical to better understand the increase for Black and Hispanic identifying students in order to sustain the gains.

SIGNIFICANCE OF MINORITIES IN GEOSCIENCE

It is well known that geoscience is one of the least diverse disciplines in science, technology, engineering, and mathematics (STEM) (Bernard & Cooperdock, 2018; Glass, 2015; Holmes & O'Connell, 2004; Holmes et al., 2015; Jones et al., 2016; National Science Foundation, 2019; Stokes et al., 2014, 2015; Velasco & de Velasco, 2010; Wilson et al., 2018) and efforts to enhance diversity among the geosciences have lagged compared to other STEM disciplines (Fry et al., 2021, Kennedy et al., 2021). However, it is not clear if the enhancement in diversity observed in all degrees from 2000-2016 is also true for the geoscience discipline or if similar rates have persisted in the graduation of students in the last five years. An exploration into recent geoscience higher education data from the state of Maryland may illuminate gender, race and ethnicity trends and could provide suggestions for national recommendations to enhance the future diversity of geoscience graduates. According to the 2020 US Census Bureau, Maryland is the most diverse state on the east coast and fourth nationally in terms of the US census diversity index (as indicated in Table 1; U.S. Census Bureau, 2020). Maryland's position on the diversity index is a significant jump from 7th place in 2010, to 4th place in 2020. Collectively, non-

Whites are the majority in Maryland; the largest race and ethnicity group is White, non-Hispanic or Latino, which accounts for 47.2% of the state population and is less than the 2020 US national average of 57.8%. Of all Marylanders, 90.39% completed a high school diploma, 40.88% (1,710,2301 and ranked 5th nationally) hold bachelor's degrees, and 19.08% (3rd nationally) have continued to an advanced degree according to the 2019 US Census Bureau Education Attainment Table (U.S. Census Bureau, 2019). The desire to pursue higher education and obtain degrees in the state is extensive and thus understanding the intersectional gender and racial graduate data from the state of Maryland may provide insight into the current and future geoscience discipline trends of a diversifying nation.

SUMMARY OF POST-BACCALAUREATE & RECRUITMENT RACE/ETHNICITY/GENDER DATA

STEM disciplines.

The 2019 National Center for Science and Engineering Statistics (NSF 19-304; https://ncses.nsf.gov/pubs/nsf19304/) report displays the racial/ethnic groups that received post-baccalaureate degrees in science and engineering. The data shows post-baccalaureate science and engineering graduate students are 75% science majors (n =466,370) and 25% engineering majors (n=154,119). The percentage of majors within the science category are 49% female and 51% male. An indication that, generally speaking within science disciplines (i.e., 34 identified in the NCES report), males dominate the discipline. The category of geosciences is represented by 2% (n=8,610) of all science post-baccalaureate graduates with females at 41% and males at 59%. As previously reported, geoscience remains one of the least enrolled disciplines and the least diverse based on racial/ethnic classification as students who identify non-white are 11% (n=947) of the total geoscience post-baccalaureate students, and women are the minority as previously noted. Consequently, a similar trend exists within the geography and atmospheric sciences disciplines where non-white graduate students are 13% (n=552) and 11% (n=159), respectively (See Table 2).

A review of the 2019 ethnic/racial data show that students who identify as White represent more than 80% of the post-baccalaureate students enrolled from 2000-2016. For example, students who identify as Hispanic or Asian had higher enrollment than students who identify as Black and American Indian. That is, 6.4%, 5.7%, 4.9%, and 0.3% of the total post-baccalaureate students represent ethnic/racial minorities in science and engineering, respectively. The Native Hawaiian/Pacific Islander group represented 0.1% of post-baccalaureate science and engineering students during the reporting period of 2000-2016. Additionally, 17% of the total science and engineering post-baccalaureate students identify as non-White and 19% of the science-only post-baccalaureate students identify as non-White.

Recruitment. Recruitment into geoscience academic positions and careers are largely, in part, driven by academia. The USM data shows for the 2006 - 2020 reporting period, that there has been no significant increase in the number of doctoral students in physical sciences (i.e., where geoscience discipline resides). The range of 555 (lowest) to 610 (highest) indicates the "sciences" need a boost in doctoral enrollment to increase the numbers of non-White faculty in the tenure/tenure-track positions. During the 2016 - 2020 reporting period, an observable upward trend from 2016-2019 was thwarted, possibly due to COVID19 in 2020, and is reflected in a decrease.

In 2016, Estrada et al. outlined a few institutional barriers needing to be addressed and interventions designed to increase engagement, commitment, and persistence in STEM for underrepresented minority students (URMs). The team recommended an increase in institutional accountability, creation of partnerships with programs designed and dedicated to elevating URM interests in STEM, that institutions address curriculum gaps and student resources disparities, and recommended that institutions increase creativity with their interventions. Although seemingly simple, these challenges still exist in 2022 as researchers and faculty grapple with recognizing how socio-economic obstacles directly affect the exposure minority students have to geoscience fields and careers.

Relatedly, the 2019-2020 Committee on Equal Opportunities in Science and Engineering Biennial report (CEOSE, 2020) suggested leadership actions parallel the recommendations of Estrada et al. (2016) above. Specifically, the report suggests that institutions address the implications of fewer minority faculty in tenure/tenure-track positions through support of a more diverse mid-career faculty populous seeking leadership positions in STEM (i.e., increase institutional accountability for diverse faculty). The report contains a suggestion to also recognize and reward faculty who are leaders in broadening participation (i.e., increasing engagement of URMs) in STEM, and encourage leadership to adopt a mindset change in relation to pursuance of projects and programs with URMs in mind (i.e., address curriculum gaps and resource disparities).

Recruitment: Geoscience graduate programs and careers

In 2021, the American Association for the Advancement of Science (AAAS) - National Science Foundation (NSF) Improving Undergraduate STEM Education (IUSE) Initiative program published a blog by Dr. Calvin Briggs under the title: How Engagement Enables Broadening STEM Participation (Briggs, 2021). Dr. Briggs expressed how STEM influences fueled his drive to bring communities, educators and administrators to STEM engagement. He recommends the community (i.e., academia) adopt a cohort model, include targeted engagement activities, and implement enhanced curriculum options. Many institutions are well versed in creating a cohort model through graduate school admission requirements, national and international societal networks, and departmental affiliations. But, as post-baccalaureate geoscience programs continue to produce more white than non-White MS and PhD academics and professionals, it becomes more difficult to recruit non-White students into a cohort.

In Fall 2020, the Institutional Research Information System (IRIS) USM data source reported 76% of total full-time faculty with an instructional appointment, 24% with a research appointment, and 0.001% with a public service appointment. The data indicates educators are in abundance leading education through engagement, a needed metric. Appendix C of the CEOSE 2020 report shows a commitment at the national funding level to foster STEM engagement through funding to not only HBCUs and Minority Serving Institutions (MSIs) (e.g., HBCUs) but also to minority Principal Investigators (PI).

The data shows during the 2009 - 2019 reporting period, NSF reported a relatively consistent funding rate for each ethnic group (i.e., American Indian, Black, Native Hawaiian, Asian, White, Multiracial, and Hispanic). The most notable difference is not in the funding rate, but in the number of proposals submitted and subsequently awarded. For example, in 2019, White PIs submitted 20,400 proposals with 6,389 funded producing the 31% funding rate. Conversely, Native Hawaiian PIs submitted 47 proposals with 14 awarded for the similarly 30% funding rate. This leads to the conclusion, although the funding rate is comparable, due to the lack of minority PIs (i.e., female, underserved, military or veteran) available to apply who are in tenure/tenure-track positions for select NSF funding, few non-White educators are available in geoscience fields to promote STEM engagement (See Figure 2). As mentioned, women continue to pursue post-baccalaureate degrees in geoscience discipline areas, but few reach the tenure-track professional pathway.

METHODS

The methodology presented herein is both a case study and narrative inquiry as the aims are to investigate the national and state landscape, study our own practice, and showcase lived experiences to support the gaps in the field. We use both case study and narrative to make evident the existing data coupled with our lived experiences, included as reflections. We employ an embedded design where separate sections of a case are analyzed to obtain valuable knowledge (Yin, 1989).

Narrative inquiry offers researchers a way to share experiences and draws on Dewey's emphasis on lived experience (Dewey, 1938). We use narrative inquiry because it reveals the professional identity of the researcher and the knowledge of those involved in the inquiry (Clandinin & Connelly, 2000; Denzin & Lincoln, 2005). While narrative inquiry methodologically reaches into the social sciences, it is the appropriate methodological choice coupled with case study, to answer the research questions outline previously.

Case Study: University System of Maryland (USM)

The USM data (https://www.usmd.edu/IRIS/FAQ/) is an aggregate of information including 11 Universities and 2 Regional Centers. The 11 universities included in this study are: Bowie State (BS), Coppin State (CS), Frostburg State (FS), Salisbury (SU), and Towson University (TU). Additionally, the University of Baltimore (UB), University of Maryland (UM) Global Campus (UMGC), UM Baltimore (UMB), UM Baltimore County (UMBC), UM College Park (UMCP), and UM Eastern Shore (UMES). The study contains 3 schools identified as a Historically Black

College or University (HBCU; Bowie, Coppin, and UMES). The study recognizes Morgan State University (MSU) as an HBCU located within the state of Maryland, but was not included by IRIS in the USM data portal. The omission is hypothesized to be due to a recently settled lawsuit (March, 2021; https://www.washingtonpost.com/education/2021/03/24/maryland-hbcus-lawsuit-settlement/) between the Coalition for Equity and Excellence in Maryland Higher Education and 4 HBCUs in Maryland (i.e., MSU, BS, CS, and UMES). Additionally, St. Mary's College and The Johns Hopkins University are not a part of the USM.

The USM data include enrollment, degrees, faculty/staff, transfer student, and workforce data. The data collection is mandated by the state of Maryland and can be found readily in data journals and routine reports. Specifically, "All data are provided by the institutions in accordance with the legislatively mandated reporting requirements by the state of Maryland and the Federal Government and are subject to audit for verification of accuracy" (https://www.usmd.edu/IRIS/FAQ/). The USM and the Maryland Higher Education Commission collect the majority of the data during the fall, spring, and summer periods to mirror The enrollment calendar.

Graduate Enrollment. The USM provides more current comparable data to that of NCSES 2019, Women, Minorities, and Persons with Disabilities in Science and Engineering Report introduced at the beginning of the paper. The data includes the discipline categories of Agriculture and Natural Resources (AGNR), Biological sciences (BIOL), Engineering (ENGR), Mathematics (MATH), and Physical science (PHYS). The 2000-2016 data from the USM system is assumed to be reflected in the NCSES report published in 2019. Therefore, the data presented represent USM data from Fall 2016 to Spring 2021. During the 2016-2021 period only 1 of the 11 USM schools, UMCP, had graduate enrollment in all 5 disciplines of AGNR, BIOL, ENGR, MATH, and PHYS. Also, UMBC was the only school with 4 out of 5 disciplines as AGNR did not have graduate enrollment during the reporting period. In the 2016 and 2019-2021 periods, TU and UMES reported graduate enrollment in 3 of the 5 categories. The TU categories are BIOL, MATH, and PHYS. The UMES categories are AGNR, BIOL, and PHYS. In the 2017-2018 periods, UMES graduates consisted of only AGNR and BIOL students. In 2016 none of the 11 universities had representation in 2 of the 5 categories, but in 2017 - 2021 UMES and UMB were the only schools to have 2 of the 5 categories represented in graduate enrollment (i.e., AGNR, BIOL for both universities). During the reporting period, CS and UB were the only 2 schools having no representation of the 5 STEM categories. Gender and Ethnicity Data. The majority of enrolled students are women (53%). Non-white students are the majority of enrolled students (59%) in Spring 2021. The USM is 43% White, 21% Black, 10% Hispanic, 10% Asian, and collectively 15% (unknown, foreign, Pacific islander, multi-race non-Hispanic) male. The USM is 39% White, 28% Black, 10% Hispanic, 9% Asian, and collectively 14% (Unknown, Foreign, Pacific Islander, Multi-race non-Hispanic) female. See Figure 3.

The American Geosciences Institute, Diversity in Geoscience (AGI, 2020), reports women were currently receiving 44% of undergraduate geoscience and 46% graduate geoscience degrees in 2019. As previously reported, the increase of undergraduate geoscience degrees was conferred to Hispanic students during the 2010-2019 reporting period. Additionally, since 2010 the number of women working as a geoscientist with a geoscience degree has decreased from 17% to 11%. The decrease is indication women are receiving degrees in geoscience fields, but working in non-geoscience occupations.

CRITICAL VIEWPOINT

Lived Experiences on Recruitment from [USM] Faculty of Color: In comparison and part of the case, women faculty within the USM articulate their experiences within STEM [education]. Three entries organized around the topics 1) barriers to recruitment, 2) lived experiences as STEM students/faculty, and 3) Geosciences recruitment.

Faculty Member #1:

Barriers to recruitment in Science/Engineering: As a Black woman in STEM, I am repeatedly asked to engage in service. I have known since I accepted this job that service would be repeatedly asked of me and the apropos response is to simply say, “no”. But I am compelled (internally and externally) to do invisible work and I have come to know that adding my effort and contributions (especially when I am capable) is simply the right thing to do. Engaging in academic invisible labor has also provided a front row seat to the inner workings of the STEM “establishment”. Much of this work requires the review of applications for awards, grants, scholarships, graduate positions, faculty appointments, etc. and the subsequent selections authorize the gateways into institutions and career ascents in academia. I have observed that barriers to recruitment are based on a heavy-handed reliance on the use of two tenets to qualify and justify applicant success. Simply put, the first tenet uses numbers. Depending on the review, these numbers range from class rank, school rank, GPA, SAT, GRE, manuscripts, conference presentations, h-index, i-index, journal ranking, funding portfolio, and you name it. Collectively, we know it is wrong. Many of us in academe espouse that numbers do not guarantee or negate success and the arguments to not use these numbers have been extensive in the literature. However, to justify our academic existence, we are collectively and (perhaps unconsciously) on an unending pilgrimage to quantify research impact; thus, when we lose one number it seems that we find a new one to take its place. Furthermore, these numbers are analogous to debt from compounding interest. One begets another and then another. For example, a high SAT score, leads to a high GPA, leads to a high GRE, leads to more awards, leads to a prestigious placement, more manuscripts in highly visible journals, and so on. We look at each of these numbers individually, but truly they are all one, compounding on each other, growing with time and interest.

The second tenet many rely on for candidate review and selection tries to mitigate the importance of numbers and depends on personal recommendations. The idea here is that if the numbers cannot be relied upon, then the committee can turn to the use of recommendation letters to judge success; the letters will provide the subjective element in the world of numbers. This idea is also laced with sophistry. As humans, it is hard to trust a letter of recommendation written by someone the reviewer does not know thus the best recommendations are typically from those already known; and the best letter writers are deemed as those who have exhibited high levels of success and visibility from tenet one (e.g., lots of numbers). In practice, this translates to "applicant A, from prestigious place X, has great pedigree and worked for famous person B, who is highly visible (with Y manuscripts, or Z awards) in our field." And thus, we are stuck in this fallacious and vicious circle that ends up choosing those who have academic currency (often bequeathed from birth) already in the circle. This selection that happens at the upper echelons of academia behind closed doors affects and trickles down to new generations of students attempting to achieve academic success but who now have a lack of exposure to diverse faculty who could act like them, look like them, sound like them, or talk like them. How can students dream of positions that they can't see themselves in? Who amongst us will be able to jump over these barriers to success to provide access? **When it comes to bias, we don't often talk about the number biases and we don't talk about the pedigree biases that keep the business of academia thriving. Perhaps the greatest barrier to recruiting diverse students in geoscience is our reliance on standardized thinking and standardized testing.** As a researcher, it is hard for me to fathom why we continue to rely on the same procedures but expect different results. We need new perspectives and new ideas to assess success. Such a movement requires tremendous effort and impact not rapidly quantified by numbers and from those that have benefited from numbers. Indeed, it is often the invisible work (not counted in numbers) behind these closed doors that consequently will shape future institutions.

Lived experiences in Science/Engineering as a student/faculty

Often, I find myself agreeing to academic meetings and committee work, ending up in rooms and discussions where I am the "only one". In the beginning of my career, I questioned my purpose and selection on the team. It was clear that my presence checked off two diversity boxes yet took up only one seat at the table. I could clearly see the advantage on paper of having me there. What I didn't see at first was my larger purpose in being there. Regardless of my internal struggles, I continued to show up and contribute. Perhaps I suffer from runt-of-the-litter syndrome and it was my personality as the youngest in the family that drove me, but I was never one to not show up and do nothing (Darn it! I may be the youngest, but I'm just as capable has always been my attitude). Perhaps it was my training in team sports? I didn't have to be the star but I refused to be the dead weight (Darn it! I'm just as capable!) Perhaps it was my immigrant family upbringing? I was committed to being here and there was no turning back. Perhaps it was my entire lived experience as a Black woman (Darn it! I may be the blackest and girliest person in here, but you know what I'm just as capable!). Many times, these were the only thoughts that let me persist on a committee. I showed up, advocated and made some type of contribution. A decade later, I know I am sometimes still asked to serve and to check boxes but I also now know that my consistency at the big table is needed. I do not rely on those currently in the room to suddenly change their modus operandi. Furthermore, **I fully understand the**

influence I have being the "only one" in the room and understand my responsibility to change it. I have found my life's impact and am content knowing it is more of a butterfly effect rather than an entity to be measured by numbers.

Geosciences recruitment: When it comes to geoscience recruitment and retention, if one is ever put in a position to enhance the Geoscience infrastructure, one must step up and advocate for diversity. Numbers do not define the success of a student. Numbers do not define people. Those of us in the system should be the foot in the door that opens a window to shed the light in closed rooms. Diversity in Geosciences is enhanced when students have faculty role models. Diversity is also enhanced when under-served and under-represented persons are provided an opportunity to eat at the big table. It is critical for those of us currently in these positions to employ aspects of our hypervisibility to the benefit of the generations that come after us.

Faculty Member #2

Barriers to recruitment in Science/Engineering: Over the course of my graduate studies, I took many classes at universities outside of my home institution through the state's consortium. The consortium allowed me to tailor my courses and graduate degree to the tools needed for success in the environmental science/geoscience field. Oftentimes, the courses were quite intimidating. Although I had great interest in the subject matter, the course description and departmental classification was a potential barrier to my enrollment and perceived success in the course. I think many potential geoscience majors who fall in the non-traditional category described above may experience a similar feeling of apprehension. This feeling is, in many instances, brought into the recruitment conversations with potential students. The barrier to recruitment now becomes addressing the apprehensions and intimidation of the subject matter students of color experience, while assuring their confidence and abilities to perform at the level needed to carry geoscience work into the future. The sentiment I describe as a barrier is not expressed by students who do not meet the criteria of a graduate geoscience program. It is the feeling of students whose current credentials make them the very students the geoscience field needs. That is, the tenacity to thrive academically in an environment where one's innovation, lived experience, and course challenges are oftentimes ignored.

Lived experiences in Science/Engineering as a student: As mentioned, I took 5 courses in my master's program outside my home institution (an HBCU) at predominantly white institutions (PWIs), one of which is considered an elite university in North Carolina. All 5 of the courses centered around environmental science (i.e. analysis of environmental samples with complex matrices, site assessments, understanding environmental organic contaminants, etc.) with laboratory components. Herein, I will describe two lived experiences that shaped me overcoming the barrier of intimation to continue my studies and pursue the Ph.D. in Soil, Water and Environmental Science at the University of Arizona upon graduation with my master's degree. In one course the Professor was intrigued by my experiences and research acumen learned while working as a student contractor at the U.S. Environmental Protection Agency in R.T.P., N.C. His intrigue quickly turned to disdain as I received close to failing grades on homework assignments directly related to my work at EPA. So much so, I asked my master's advisor to review my answers as I understand grading is subjective. The result was a letter written to the Professor by my master's advisor reminding them of their commitment to the consortium. Specifically, a reminder that educating all students equally was a charge accepted when choosing academia as a career. My grades did not improve, but I received the "B" required to matriculate through the program. In the same course, the laboratory component required students to work as partners to complete experiments. I was partnered with a student who I would identify as being Asian. As customary, I attempted to collaborate on tasks to complete the experiment but the student refused to work with me. They stated I "did not know what I was doing" and chose not to partner with me even with the understanding I performed the experiment tasks as part of my paid duties at EPA. The result was the teaching assistant asking me to complete all labs for the course independently as all other classmates were partnered. These two lived experiences shaped my thoughts on how I chose to pursue science and particularly increased my understanding of how ethnic, racial, and cultural differences shape one's way of conducting, teaching, and pursuing environmental science and geoscience. The experience would not thwart my success, but be the driving force behind my pursuit of the PhD and subsequent decision to pursue academia as a career pathway.

Geosciences recruitment: Recruitment is a vital component for a Professor intending to matriculate through the tenure process. A faculty member will recruit, vet, and subsequently select a student(s) to participate in research projects of their discipline, expertise, and interest. This can be a daunting task for faculty of color in a predominantly white-male dominated field. For example, if I attend a national or international conference and join the sessions centered around environmental science, remediation, hydrology, contaminant transport, or a similar topic area, I, in many instances, am the only Black American in the room. In 10 plus years of attending conferences, I occasionally saw an African student in my field. More recently, I've been quite excited to see Hispanic students in these geoscience sessions. This presents a challenge for a geoscientist of color to recruit as generally speaking, 1. Some White students aren't respectful of my education and expertise, 2. Many white faculty question my education and expertise from the HBCU although the PhD is from a PWI, and 3. I can't recruit racial/ethnic demographic groups that aren't present. But, my co-authors and I have responded to the call of funding agencies to actively recruit students to geoscience.

Through the creation of the PEARLS (Providing Educational Access to Research and Learning in the geoSciences) program funded by the National Science Foundation, we aim to recruit non-traditional geoscience students to the field and careers.

Faculty Member #3

Barriers to recruitment in Science/Engineering: I started my undergraduate career as a pharmacy major. I changed my major to biology after interning in a local pharmacy near my hometown. My experience as a college STEM student was positive as I had several students and faculty around me in a supportive, HBCU environment. I turned down admission to other institutions given their lack of emphasis on diversity and inclusive experiences at the time.

What I have learned from working on recruitment of STEM [education] over the past decade, is that the chilly climate that the literature describes in higher education continues to persist. As a mentor in the university's URM STEM program, there have been several accounts of microaggressions from faculty who dismiss the experiences of students who are not connecting to the climate of their classroom, their content delivery, or their engagement during office hours. Students from diverse backgrounds look for affinity groups for support, such as multi-ethnic student associations, sororities and fraternities, and minority-centered STEM groups (e.g., the National Society of Black Engineers (NSBE). The agency and social capital and networking that individuals from non-minority groups bring to the classes from high school, or from other graduates (e.g., access to old exams or syllabi) create an unequal field for URM in STEM.

Lived experiences in Science/Engineering as a student:

I grew up in a college town with a flagship, top tier public institution to which I didn't even apply. I was the only Black person in AP Calculus, AP Physics, AP Biology, and every other advanced course that I enrolled in during my high school years, with the exception of a ninth-grade social studies course. There was only one other person of color in those courses, a student in my AP Chemistry class whose parents were studying at the local institution. I was a high-performer and obtained the highest grade or ranted in the top one percent in every single one of my science and mathematics classes, The exception was Biology, I understood it the least, so that is one reason that I chose it as a major. Chemistry and Physics are two of my favorite subjects. We were a competitive group of peers, most of whom stuck together (because of how tracking works) since our elementary and middle school talented and gifted class. We had four valedictorians in my high school class with perfect grade point averages.

Despite my high performance, the geosciences missed me by miles early on for many reasons. One example includes the lack of mirrors (see Dr. Ruby Bishops work on mirrors and windows). I had three black teachers in my PK-12 experience. One was my mom; another was my kindergarten teacher (mom probably demanded my placement in her class) and the third was an African American history course that parents of students of color at my high school fought for (citation-redacted). In addition to a lack of mirrors among PK-12 faculty, the Future Farmers of America club had zero students of color. **I spent the first five years of my life on my grandfather's several hundred-acre farm, around horses and agriculture, and I could have contributed greatly as my father and grandfather were some of the very few Black cattlemen in my state. The faculty advisor seemed quite disinterested so I took my talents to Future Homemakers of America (an advisor of color) and student government.** STEM instruction in high school did not intrigue me, the textbooks and wall images were all White men. My high school teachers did not talk to me about college nor did they make clear the colleges they attended. If it weren't for my competitive drive and my father's ongoing instance to engage me in outdoor learning and science, I would have not majored in a STEM field.

Geosciences recruitment: Making clear the resources that are available in the geosciences Remains a critical endeavor for. Faculty who are seeking to diversity the field. By faculty, I mean from Pre-Kindergarten to graduate school. The opportunities within the field are plentiful if we make them accessible and visible to all students.

In sum, universities with geoscience programs fail to attract talented students of color, who live in their own backyard, I have observed this at three institutions. Also, there is little evidence that STEM PK-12 teachers help their alma maters attract talented students from under-represented groups into the geosciences although teachers should certainly receive credit for preparing students well for STEM fields. Challenges to create opportunities for high school and transfer students to move into geosciences including some of the geoscience fields within teaching and education (e.g., biology, environmental science, agriculture, earth science) continue to exist. Additionally, the content in my PK-12 classrooms were not culturally responsive (See Gay, 2018), culturally relevant (See Ladson-Billings, 1995; 2021) nor culturally sustaining (See Paris & Alim, 2017). As an anti-racist STEM educator, I am working to change that.

AUTHOR VIEWPOINT

Our case study provides evidence that, as academics, we must do better to significantly increase the number of underrepresented groups in the geoscience field. The narratives presented by the three faculty women of color provide qualitative evidence of the barriers to recruit and retain underrepresented groups in geoscience and interdisciplinary fields. The critical viewpoint is experiential learning, inclusive teaching practices leading to the removal of the “chilly climate”, and geoscience programmatic scholarships may not be enough to increase the number of underserved and underrepresented groups into geoscience fields and careers. A growth mindset of academic recruiters, counselors, and advisors and research faculty that gives the first-generation, non-competitive SAT/GRE score, and or non-traditional student applicant a chance is the path least traveled by academics.

The least desired pathway requires academics to look introspectively at how they intrinsically view students from underserved and underrepresented backgrounds and communities. The pathway may contain many students from low-income backgrounds with little familial support, 4.0 undergraduates from a small liberal arts college with limited resources for STEM education, and immigrants from varying countries seeking an opportunity to better their family and create a legacy for the future.

How might we, as academics, aid students and subsequently the geoscience field? Say, yes. That is, take a chance on a student who may NOT be in the top 1%. Take a chance on the student who may be shy and less articulate, but has strong work ethic and “good grades”. Take a chance on a student who may not know all the answers to your technical questions, but is willing to go and find the answer for the research’s sake. We challenge the geoscience education and research community to evaluate beyond the boundaries of SAT/GRE scores, exceptional letters of recommendation, and coveted internships at prestigious programs to seek students whose personal drive and determination compel you despite their perceived deficiencies. As for many academics and students, the hurdles to apply, make contact, or register may have been quite significant.

Faculty Mentoring

The traditional mentoring methods for faculty ask that we seek “the best of the best” from the “top tier schools” who studied under “XX, a ground-breaking researcher” in the discipline field. What if academics create an alternative mentoring method that looks at mentoring from a wider lens. How might this look? 1.Recruit potential PhD students from Historically Black Colleges and Universities. 2. Eliminate the “we can’t find them” narrative. 3. Design and implement a mentoring and retention plan specific to the incoming faculty of color to serve as a “living” document for future faculty. A growth mindset that benefits all potential geoscience academics and students is our RFP (request for proposal) to the readers as it will never be rejected.

DISCUSSION AND RECOMMENDATIONS

Although the narrative inquiries stand on their own, as women of color in STEM, our experiences as both faculty and students can assist institutions who want direct accounts of the occurrences, barriers and highlights that occur even in a state with racial and linguistic diversity.

Below is a list of recommendations as a result of the analysis of the case and narrative submissions.

1. Attract and retain post-baccalaureate students to STEM

To attract students into geoscience careers many administrators, faculty, and educators Understand engaging students through targeted programming can leace URMs to geoscience fields (Bhattacharyya & University of Wisconsin-Whitewater, 2016; Carrick et al., 2016; Ghion et al., 2018; Hanks et al., 2007; Kampe & Oppliger, 2011; Sherman-Morris & McNeal, 2016). The programming includes pedagogy changes in the PK-12 curriculum, experiential learning techniques, and early, ethnically relevant, exposure.

In 2021, Carter et al. report on the altruistic factors of “helping people and the society” and “helping the environment” as being rated the most important in reference to the desire to have a meaningful career that gives back to the community for undergraduate students at an urban, Hispanic-serving, Research 1 designated University in the southwestern United States. They go on to state the allure of working outdoors does influence choosing the environmental and earth science (i.e., geoscience) fields, but is not the deciding factor for females and minorities choosing geoscience disciplines. In actuality it may deter URM students as all geoscience work does not occur outdoors (Johnson, 2018; Sexton et al., 2018; Stokes et al., 2015). Their research also shows the survey respondents strongly agree that “geoscience is less positively perceived compared to biology or engineering” and view the geoscience field less positively as it relates to “one’s ability to make a lot of money compared to other STEM fields.” The Pew Research Center analysis of 2017-2019 American Community Survey found that the average STEM, full-time worker, and aged 25 or older made $77,400 in 2019. Whereas, the non-STEM job paid, on average, $46,900. Additionally, Asian men in STEM on average made $103,300, the highest. Black women and Hispanic women equally made the least average STEM salary at $57,000 (Pew Research Center, 2021).

The measures implemented to attract, recruit, and retain undergraduate URM students into geoscience fields, can be expanded to graduate programs. Few studies show why in some instances, the STEM undergraduate degree is conferred, but the career or graduate discipline is non-STEM. The 2019 U.S. Census Bureau American Community Survey reports 28.6% (+/-0.2%) of workers with a bachelor’s only in STEM work in a STEM occupation, 4.7% (+/-0.1) with a bachelor’s only in STEM work in STEM-related and 66.8% (+/-0.3) with a bachelors in STEM work in a non-STEM occupation. Similarly for workers with a graduate degree in STEM and working in a STEM, STEM-related, and non-STEM occupation is 26.5% (+/-0.2), 16.9% (+/-0.2), and 56.7% (+/-0.3) respectively. The Census data indicates that those who receive a graduate degree (i. e. post-baccalaureate) are more likely to select an occupation in a STEM or STEM-related field than workers who have a bachelor's only degree in STEM. Consequently, 32.4% (+/- 1.6) of total STEM, bachelors only in physical science (i.e., biological, environmental, and agricultural sciences) and 30.3% (+/- 1.4) of total STEM, graduate degrees in physical sciences are in STEM occupations.

The Census gender data shows a similar trend in which approximately 60% of men and 40% of women earn bachelors only and graduate degrees pursue occupations in STEM. The Census ethnicity data shows 7.0, 6.7, 11.7, and 72.0% of Black, Hispanic, Asian and White bachelors only degree holders in STEM obtain STEM occupations. More specifically, a decrease in the percentage of minorities with geoscience degrees working as geoscientists (23% to 15%) has occurred since 2010.

2. Identify the Gaps (The lack of data)

Numerous studies have shown that students from underrepresented groups who take a traditional introductory geoscience course have a decreased interest in geoscience at the end of the course(Riggs & Semken, 2001) due to less than optimal experiences such as an uninviting, chilly climate (Simon et al., 2017). The uninviting, chilly climate, is postulated to be, a reflection of an educators' siloed experiences and teaching methods for students who are, more recently, non-traditional. That is, the non-traditional student may be a veteran, starting a second career, switching majors, or a student who took 1 or more gap years prior to their first semester. The lived experiences of the individuals may be vastly different from those of the instructors, thus making the course content unrelatable. This gap may seem wider for minority students who are seeing the course content for the first time.

Geoscience is non-traditional by nature. That is, traditional science and engineering (i.e., physics, biology, chemical engineering) can overlap with geoscience (a.k.a. Earth science; geology, paleontology, seismology, meteorology, volcanology). Complex pathways may fall in the gaps of traditional/siloed disciplines within geoscience. Through the interdisciplinary nature of geoscience, an environmental scientist or hydrologist whose course background excludes them from the traditional science and engineering disciplines can be considered a geoscientist due to the nature and application of their research. The data on these interdisciplinary individuals is lacking in the statistical representation. This lack of data presents the current question of where are the minority female geoscientists. The 2020 American Geosciences Institute data brief (American Geosciences Institute, 2020) reports the dataset from the U.S. Bureau of labor and Statistics tracks demographic data only if the "occupation or industry has over 50,000 employed persons".

This presents a challenge for researchers attempting to track those in environmental science and geoscience careers. Particularly due to the geoscience workforce in aggregate accounts for more than 400,000 employed persons. The report states, "the profession spans many occupational categories that on their own do not meet threshold requirements for reporting of these demographic data". Amongst the geoscience-related categories, geoscience and environmental science are the largest occupational categories representing one-fifth of those reported as "geoscientists."

3. Closing the Gaps (Identifying us)

Engagement in STEM (i.e., geoscience) looks similar to engagement with an industry expert, community leader, or responsible party contractor. It requires the educators (i.e., faculty and researchers) to go out into the field to not only assess the need, but help the community come up with a shared, viable solution. For example, each year across the country, public schools are holding STEM or Science Fairs and a percentage of these schools are minority-serving. The science teachers are looking for judges to encourage and expose students to STEM fields as they decide their future. The STEM fair is an opportunity for non-white faculty to not only engage with minority students on their research interests, but also an opportunity to impart their passion for STEM as a means to encourage continued interest in the fields.

Limitations. The authors recognize the case study does not encompass higher educational systems outside the designation of one state and highlights primarily one Research-intensive institution and may omit extremes that exist in STEM granting degree institutions designated as private, or even public liberal arts universities or colleges. The authors also recognize the omission of quantification of minority faculty in the USM Case Study. The authors caution readers not to generalize the data due to the limited sample size. The authors' home institution provides racial/ethnic data on faculty, but not accessible at the USM level. The authors recognize the data presents binary gender designations and exclusion of non-binary genders. The exclusion of non-binary gender data is not intentional nor a reflection of the authors views.

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