Research on Access and Success of Under-Represented Groups in the Geosciences

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Introduction

The geosciences as an allied group of fields touch virtually all aspects of the human enterprise: locating and providing water, energy and mineral resources; assuring a safe and resilient environment for civilization; and providing an understanding of how the Earth system functions today, in the past and into the future. Given how the geosciences touch the lives of all people, it should also be a field that is representative of all people, but this is not yet the case (Figure 1). Especially with the global importance of the geosciences growing and the geoscience workforce projected to encounter shortfalls of qualified practitioners in the coming decades, it is imperative that the geoscience education research community frame and investigate central questions that can help increase the diversity of the geosciences at all levels. We must find ways to attract all kinds of students, especially those from under-represented groups to our sciences and build programs, experiences and careers in which they thrive. We deliberately embrace the notion of "attract and thrive" after the work of Roberto Ibarra and colleagues (e.g., Ibarra, 2001, 1999) that rejects the notions of "recruit and retain"—involuntary, or at least passive, actions that happen to under-represented people in the field—and embraces more active and supportive concepts of attraction and thriving. The theory of multicontextuality advanced in their work acknowledges the effect of complex, interwoven identities of under-represented students at they learn in and interact with STEM fields, and the explicit importance of institutional attention and action to identify and lower barriers to success while providing necessary support. These ideas also provide a way forward in addressing the challenges of diversifying STEM fields shared across

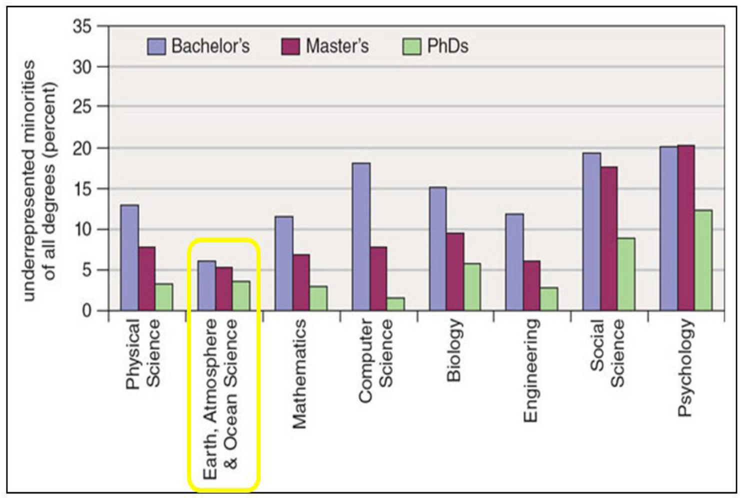

Figure 1. Ethnic and racial diversity are extremely low in geoscience degrees at all levels. A recent report from Bernard and Cooperdock (2018) indicate that, while significant advances in gender diversity have taken place, no progress on ethnic and racial diversity in the geosciences has been made in 40 years at the national level at the doctoral level despite measurable gains at the undergraduate level as reported in Wilson (2016). Modified from a figure in Johnson and Harrison Okoro (2016), based on data in National Academy of Sciences (2011).

all science and engineering fields, as articulated by the National Academies report on “Expanding Underrepresented Minority Participation” (2011). The research questions and challenges posed in that report undergird much of the analysis and synthesis we pose in our Grand Challenges, in addition to work specifically in the geosciences.

The research challenge boils down to two essential and interdependent perspectives, specifically: (1) the point of view of the individual students, faculty and professionals as they manage their own internal balance of identities as they traverse

curricula, programs and career pathways, and (2) a view that captures system-wide interactions around the individuals at all stages, including family, culture, department, university and society. The Grand Challenges focus on these two approaches.

Grand Challenges

Grand Challenge 1: Supporting the Individual in the Geosciences: How can we recognize and support the individual identities and personal pathways of students as they are attracted to and thrive in the geosciences?
Many of these issues are now well-informed by research from outside the geosciences, and we have the programmatic experience and our community have access to more nuanced theory to make significant steps forward in understanding program design and student pathways.

Grand Challenge 2: Geoscience Community Efforts to Broaden Participation: How can the geoscience community capitalize on evidence from different scale efforts to broaden participation?
Solutions and programs must scale appropriately to the situation and communities at hand. Success and solutions in diversity has no singular solution - healthy programs and communities who are diverse and welcoming exhibit sets of characteristics which are repeated

Grand Challenge 1:

Supporting the Individual in the Geosciences: How can we recognize and support the individual identities and personal pathways of students as they are attracted to and thrive in the geosciences?

Rationale

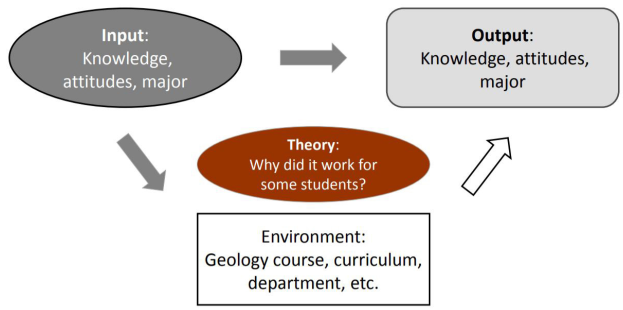

Figure 2: A highly generalized, schematic model showing points of investigation to address this Grand Challenge using an Input-Environment-Output model for student experience. Model modified from Callahan et al., 2017.

Many of these issues are now well-informed by research on the structure and nature of student science identity from outside the geosciences (cf. Jones & Abes, 2013), and we have the programmatic experience and our community have access to more nuanced theory to make significant steps forward in understanding program design and student pathways. For a review of background theory and application to the geosciences, see Callahan et al. (2017). A fundamental aspect of developing expertise in any discipline is the process of learning the language, normal practices, and habits of thinking specific to that discipline (Posner, 1988). While community college and undergraduate geoscience programs are arguably not producing experts—based on common definitions of expertise (e.g. Ericsson, Krampe, & Tesch-Römer, 1993)—such programs do provide a substantial foundation for later training, education, and work experience. The geoscience community has articulated a suite of skills and understandings that students should acquire during their undergraduate education (Mosher, 2015); examples include: strong written and verbal communication skills; integration of observations in the natural world with experimental or modeling data; and solving problems requiring spatial, temporal, and uncertainty interpretations. The level to which students achieve these skills and understandings is one measure of a student's success in developing expertise. This metric for success, however, assumes equivalence of experiences in education; it makes no differentiation for the reality that students not only arrive in the geosciences along different pathways (Sherman-Morris & McNeal, 2016), but also carry with them other identities beyond the shared identity of a geoscientist. Thus, we propose the following question as an area in need of further research in order to improve access and success for underrepresented students in the geosciences: How can we recognize and support individual identities and personal pathways of students as they are attracted to and thrive in the geosciences? This broad question has two main facets in need of explication.

Recommended Research Strategies

1. If we wish to recognize and support under-represented students' identities in the geosciences, we need to have a richer understanding of their lived experiences as members of the community. Callahan et al. (2015, 2017) argue for the importance of and suggest multiple theoretical frameworks from the social sciences that may be useful in this effort; for instance, Baber et al. (2010) used the theory of self-efficacy to investigate the success of summer research programs for recruiting minority students to the geosciences. Theoretically-driven research can build our understanding of whether

and how students from underrepresented groups develop their geoscience identity alongside existing identities. In what ways are those identities compatible and in what ways are they in conflict?

2. If our intent is to increase diversity in the discipline, we may also need to ask uncomfortable questions about how the "norms" of the community impose barriers to students from under-represented groups at all points as they flow through programs and curricula. Figure 2 presents a highly generalized, schematic model showing points of investigation using an Input-Environment-Output model for student experience. For example, photographs on websites for geoscience departments commonly feature outdoor environments, more men than women, and almost everyone is white (Sexton et al., 2014); are websites unintentionally sending a message of who fits the accepted role of an expert geoscientist and who does not? How is privilege implicit in the structure of programs and curricula? How can we integrate culturally-responsive pedagogy into geoscience curricula (e.g. Gay, 2010)? Ultimately, we recognize that how we define success may not change so readily; we posit, though, that there are ways to broaden our approach to how we move students toward geoscience expertise.

Grand Challenge 2:

Geoscience Community Efforts to Broaden Participation: How can the geoscience community capitalize on evidence from different scale efforts to broaden participation?

Rationale

Solutions and programs must scale appropriately to the situation and communities at hand. Success and solutions in diversity has no singular solution - healthy programs and communities who are diverse and welcoming exhibit sets of characteristics which are repeated. Studies have shown that while overall success in recruiting and retaining underrepresented minorities has only improved modestly at the undergraduate and masters level (Wilson, 2016) and has not improved at the doctoral level nationally (Bernard & Cooperdock, 2018), research suggests that certain efforts have been more effective that others. Implementations can be divided into large-scale implementations that are national in scope and focus on change within an entire science community and those that are smaller scale and local in scope aiming for change on a particular campus or department. The Macrosystems Framework (Wolfe & Riggs, 2017) below (Figure 3) incorporates the important elements and interactions between the broader "System" and the "Individual."

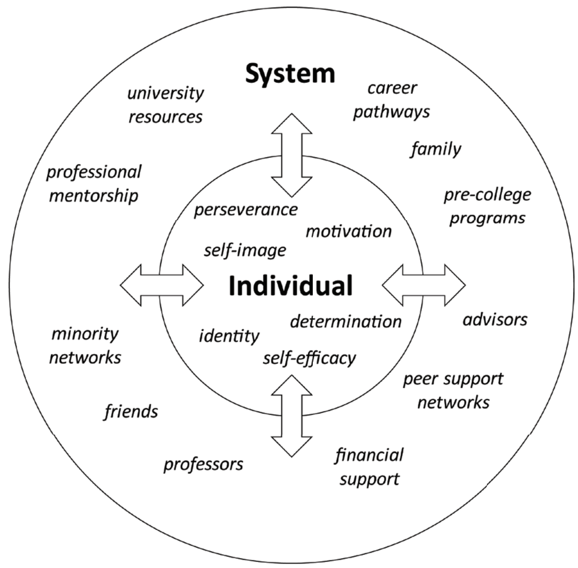

Figure 3: Macrosystems Model. This model is a graphical representation situating the individual student (or faculty member) within the many systems which surround them in an academic setting. The arrows show the bi-directional continuous interactions that shape the individual and the system and influence the direction and persistence of both. The italicized features illustrate a few of the specific examples of elements of the individual and system. These will all be engaged in interactions between an individual and the system around them, and should be taken into account when working to understand and optimize supportive programs for advancing students from diverse backgrounds. From Wolfe and Riggs, 2017.

Ambiguity about where to aim resources derives in part from failure to differentiate what kind of approaches and resources should be afforded to each and using the same measures of success for both broad community-wide (e.g. Peer et al., 2004) and more local, focused or campus-scale efforts (e.g. Blake, Liou, & Chukuigwe, 2013; Blake, Liou, & Lansiquot, 2015; Semken, 2005) . Research literature examining both approaches illuminate ways to focus efforts toward success and suggest that both can contribute to success in recruiting and retaining underrepresented minority students and it is up to the geoscience community to incorporate what has been learned into what we do. Both large scale and smaller local efforts must both be valued, funded and facilitated if the Grand Challenges of providing access and success for underrepresented students in the geosciences are to be met.

Recommended Research Strategies

1. Efforts to broaden participation that are likely best for large-scale implementations include those that critically examine the way the geosciences are viewed by underrepresented minority students. This is important when students first make decisions about what major to pursue and second as students internalize some sort of personal reconciliation between those elements of geoscience study which appear personally foreign or culturally off-putting and elements of a value proposition

that can be accepted. Making our disciplines more relevant and more welcoming to a broader group of students will require a broad national geoscience community effort. Refashioning what is relevant about of our disciplines to the cultures we are trying to reach and discarding those things that keep or drive students away will need to be a grand scale effort with everyone on board.

2. While implementation will come down to what goes on locally in departments, there is a need for the broad geoscience community to articulate the need for change and suggest goals and a timeline for them to be reached. There is a need for community consensus about how to illustrate career paths so that students (and their families) have some sense that a rational paths exist and that future progress is not haphazard. Templates for how to access and maintain financial support need to be refined and broadly disseminated. Guidelines for and examples of professional mentorship need to be shared. Professional networks for faculty, particularly those working with underrepresented students at community colleges and minority serving institutions, need to be strengthened where they exist and new ones initiated. There must be opportunities for faculty to work together to share student success and engage in student learning focused professional development experiences. Unfortunately, published analyses about what works and what does not in all of these activities is sparse at best, and focused research on geoscience education systems is required at all scales.

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Figures

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