

Commentary

Improving diversity and inclusion in STEM graduate education

Let's say you are a faculty member in a physics or astronomy department and for the first time will be serving on the graduate admissions committee. You have heard a lot about the problems our fields have with diversity. For example, questions have been raised about the usefulness of the GRE exam in determining who should be accepted to PhD programs. Many of your colleagues believe the GRE says "something" about candidates' abilities, and they ask, "How will we get through hundreds of applications without some objective metric to sort them?" Vaguely uneasy with those arguments, you believe something should be done, but you are not sure what.

The uncertainty, discomfort, and downright fear around addressing issues of inclusion constitute real and unnecessary barriers to increasing diversity in our fields. The fields of STEM (science, technology, engineering, and mathematics) have had a glaring diversity problem for decades, and progress has been uneven. According to an NSF report,¹ only 37% of PhDs awarded in STEM in 2016 went to women. In astronomy the figure is even lower, at 31%; and in physics the number is lower still, at 18%.

The situation is much worse for people from underrepresented minority groups, including American Indian or Native Alaskan, Black or African American, and Hispanic or Latinx students. In 2016, 12% of STEM PhDs awarded to US citizens and permanent residents went to members of those groups, and only 6% in physics and astronomy. Those numbers are well below 31%, the US Census Bureau's estimate of those groups' representation in the US population that year.

But back to your dilemma. You need help convincing your colleagues on the admissions committee, and you will find it in the recent report by the American Astronomical Society (AAS) Task Force on Diversity and Inclusion in Astronomy Graduate Education,² cochaired by myself and Gibor Basri of the University of California,



SCHOLARS FROM CAL-BRIDGE, a joint California State University–University of California bridge program to help physics and astronomy students from participating campuses pursue a PhD in astronomy, physics, or a related field. Although Cal-Bridge targets UC PhD programs, about 60% of the scholars go to PhD programs at other institutions. (Photo courtesy of Kerean Povich.)

Berkeley. The report provides a road map for addressing known barriers to diversity and inclusion in astronomy, most of which are also found in physics and other STEM fields. The major barriers include admissions practices, such as the GRE exam, that are based on flawed metrics and weed out nontraditional candidates; low retention rates caused by department climates that are not always welcoming to women and people of color; and the lack of systematic data to track progress.

To address admissions, retention, and data collection, the AAS task force divided into three working groups, one to address each area. In the end, the entire task force met to integrate the work of the three groups into a coherent whole. The report is designed to be a practical guide for departments, with specific recommendations in each area. More than half of the report is appendices containing detailed recommendations and tools that some departments are beginning to use to improve their admissions practices and department climate.

The task force included members of the astronomy community from a wide variety of schools and programs: research universities, minority- and Hispanic-serving institutions, and bridge programs

that help students from traditionally underrepresented groups matriculate into PhD programs. In addition, three nationally recognized social-science experts advised the task force, one on each area of concern. Together they made sure that all recommendations were based on evidence or best practices.

As a new member of the admissions committee, you can use the AAS report to become a well-prepared, informed advocate for diversity. Specifically, you can take into committee meetings the report's key recommendations pertaining to admissions, such as "implement evidence-based, systematic, holistic approaches to graduate admissions, based on the existing literature as well as on self-study when possible" (reference 2, page 12).

But what is holistic admissions, and how can it be implemented? The report describes a three-component model that was developed by one of the task force advisers: "Holistic review in graduate admissions should be 1. *comprehensive*, considering a variety of student qualities including their socioemotional/non-cognitive competencies, 2. *systematic*, articulating how reviewers should look for these qualities, and 3. *contextualized*, considering how students' characteristics

and achievements reflect not only their potential, but also the opportunities they have had, their developmental trajectories, and known sources of error in standard metrics" (reference 2, page 12).

The key idea is that traditional measures used in admissions are incomplete and do not weigh characteristics for success as a physics or astronomy researcher as opposed to as a classroom student. Those characteristics include perseverance, creativity, conscientiousness, realistic self-appraisal, a focus on long-term goals, and leadership.

A powerful new study of various factors contributing to PhD completion looked at more than 2000 US students receiving physics PhDs from 27 programs over a 10-year period.³ It found that the physics and verbal GRE tests showed no statistically significant relationship with PhD completion. The range of physics scores varied from the 10th percentile to the 90th, so the lack of correlation is not due to a restricted sampling range.

The GRE-Q (quantitative measure) showed a barely statistically significant correlation with PhD completion. Students scoring in the 90th percentile for the GRE-Q are only 9% more likely to receive their degree than those scoring in the 10th percentile, so even that test is a poor tool for predicting success in graduate school. The use of the GRE for PhD admissions becomes even more problematic when one considers that scores on all three GRE tests—physics, verbal, and quantitative—show strong correlations with gender and ethnicity in a way that greatly reduces diversity.^{3,4}

So, without the GRE to guide you, how do you make admissions decisions? The AAS report suggests that "programs should reduce reliance on standardized tests, structure information gathered via recommendation letters, and incorporate assessment of socioemotional competencies (i.e., non-cognitive skills). Faculty reviewers should also approach prospective students as learners, not only as research or teaching assistants, and evaluate them for their potential to grow into great scientists, not only for their accomplishments to date. *Because opportunities to learn and conduct research vary considerably with forms of social privilege, it is critical that programs working to mitigate inequalities not simply admit the students with the most impressive credentials*" (reference 2, page 13; emphasis added).

In particular, the use of rubrics to evaluate candidates can ensure that reviewers consider the many characteristics of successful PhD students, including the socioemotional competencies mentioned above. Toolkits, some of which are included in the appendices of the AAS report, can guide admissions committees in assessing these skills as a complement to more traditional measures such as GPA, essays, and letters of recommendation.

The AAS report contains examples from PhD programs whose holistic admissions practices have begun to show success in boosting diversity without reducing student quality. In fact, evidence from some of the programs suggests that the attention to socioemotional skills has increased the quality of PhD students. Although implementing such practices may take more work than simply sorting by physics GRE score, that extra effort should vastly improve the resulting PhD pool.

The time is long past to make the physics and astronomy communities representative of the society we live in, and thereby utilize the full potential of society's scientific ability. Multiple factors have impeded progress in achieving that goal, but

the largest is probably ignorance of the real characteristics that influence success in graduate school. Most physics and astronomy faculty members assume they know what a successful PhD student looks like, but such assumptions are largely untrue or untested. If physics and astronomy faculty seek out better information and implement the types of practices recommended in the AAS report, then we may yet succeed in our shared goal of improving diversity and inclusion in our fields.

References

1. National Center for Science and Engineering Statistics, Directorate for Social, Behavioral and Economic Sciences, *2016 Doctorate Recipients from U.S. Universities*, NSF (2018).
2. A. Rudolph et al., *Final Report of the 2018 AAS Task Force on Diversity and Inclusion in Astronomy Graduate Education*, American Astronomical Society (2019).
3. C. W. Miller et al., *Sci. Adv.* **5**, eaat7550 (2019).
4. C. Miller, K. Stassun, *Nature* **510**, 303 (2014).

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LETTERS

For love and physics

Toni Feder's photo story "Snapshots from the life of Cécile DeWitt-Morette" on the PHYSICS TODAY website (10 October 2017) brought back fond memories about my mother and more than a few smiles! I would like to correct one anecdote, though, which I gather came from my sister Chris when she provided background on our mother without knowing it was incorrect.

The error, I know, would have saddened Cécile had she read it. It had to do with her reason for not marrying Peng Huan-wu, her adviser at the Dublin Institute for Advanced Studies in 1947. The story says it was because he wasn't French, but that was not the case.

Cécile did indeed tell us she used the excuse that our father, Bryce DeWitt, was not French (or Catholic) for her initial reluctance to marry him, though they wed in 1951. But her reasons for not marrying Peng were quite different. She was very much in love with him and

would have married him, but it was the late 1940s and he was returning to China, which was in the midst of a civil war. When he left, he offered her a one-way ticket to Hong Kong and told her that from there he could get her into China. In her words, recorded during a series of interviews I filmed with her in 2003, "I chickened out. Honestly, I thought I'd be a problem for him in a country in turmoil and not speaking the language. And I was scared by the possibility that I would never be able to go back to France."

So her fear of being a burden to him as a foreigner in China and the idea of not seeing her country again were what led her to turn him down.

They continued to communicate even after he returned to China, until early 1950. His letters, which Chris recently uncovered, reveal a generous, wise man who continued to love her and to hope she would accept his offer but who knew it would be too difficult for her. That she kept his letters reveals the depth of her feelings toward him. She told me that she visited the newly opened China in 1982 as part of a US scientific delegation, and even then, when she saw him again for