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Commentary

Policies and Practices to Improve the Chemistry Graduate Student Experience: Implications of the ACS Survey of Graduate Students

Celeste M. Rohlfing, Geraldine L. Richmond, Maya Noviski, Priscilla Lewis, and Jean Stockard*

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ABSTRACT: STEM graduate education is vitally important in producing the talent needed to fuel our economy and provide solutions for the challenges we face in emerging diseases and climate change. Yet recent research indicates that women and students who identify as members of minority groups traditionally underrepresented in STEM face extraordinary challenges in their graduate careers. This commentary describes ways in which chemistry graduate education could become more supportive and inclusive through changes by graduate students, faculty, departments, funding agencies, and professional organizations. As a result the scientific workforce could utilize the full range of available talent and become more productive.

KEYWORDS: *Graduate Education/Research, Women in Chemistry, Minorities in Chemistry*

The COVID-19 pandemic highlighted the crucial role science plays in maintaining public health and well-being. STEM education is central to this pursuit, producing the talent needed to fuel our economy and providing solutions for the challenges we face in emerging diseases and climate change. Growing evidence indicates that scientific endeavors are most innovative when they involve a diverse workforce, one that incorporates all segments of society and is supportive and inclusive. It is well-documented that organizations with more diverse leadership and teams are more successful than those homogeneous in gender, race, and ethnicity.[1,2]

However, data indicate that the scientific workforce in the United States has far to go to reflect the diversity of our nation's population. Since 2000, about 40% of all STEM bachelors degrees have gone to women, but in the most recent year for which data are available (2017−18), women received only 34% of the STEM PhDs, a percentage that has been relatively flat for the past 10 years. The percentage of degrees in STEM awarded to students who identify with a racial−ethnic group traditionally underrepresented in these fields (underrepresented minority, URM) is gradually increasing, but still far below representation in the population as a whole (approximately 30%), especially at the highest levels.[3] In 2017−18, students who identified as a URM received 19% of bachelors degrees, but only 12% of the PhD degrees. The disparities are even more apparent in the gender and race−ethnic composition of STEM faculties of colleges and universities. Even though numbers have gradually increased over time, the most current data indicate that less than 20% of tenured STEM faculty are women and less than 10% identify as URM.[4−7]

Our analyses of an ACS-sponsored survey of more than 2,000 chemistry graduate students, summarized in a companion article,[9] suggest that an unwelcoming and unsupportive environment in the graduate experience may contribute to these ongoing disparities. We found that women, and especially those who identify as URM, were less likely to receive the desired support from their advisors. Women were also less likely to believe they would definitely finish their degree, pursue a postdoc, or seek a career as a professor in a research-oriented university. Those who identified as URM were less likely to receive support from peers or postdocs, or to have funding sufficient to meet the cost of living where they live, especially in the later years of their program. Thus, URM students in the later years of their program were more likely than other students to rely on personal financial resources and loans. Despite the lack of peer support and heavy financial burdens, those who identify as URMs were more likely to definitely plan to finish their degree and pursue a postdoc. However, in doing so, they may accumulate extensive financial debt. Our examination of students' descriptions of their graduate experiences and their suggestions for change discerned no differences by gender, identification as URM, or department rank. This suggests that issues in chemistry graduate education are widely recognized and deeply embedded within the discipline's culture.[8,9]

These results have serious policy implications. We believe that there are numerous ways in which chemistry graduate education could become more supportive and inclusive, producing a more diverse and productive scientific workforce that utilizes the full range of available talent. Changes could, and should, be enacted by graduate students, faculty, departments, funding agencies, and professional science organizations.

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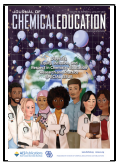

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GRADUATE STUDENTS

We believe that graduate students can help alter the nature of their graduate programs. One of the most disturbing findings of our analysis was the extent to which students who identified as URM did not receive support they desired from peers or postdocs with whom they worked. Scientific breakthroughs are facilitated by interactions between colleagues and by sharing ideas, criticisms, and feedback. Such interactions also help temper the inevitable ups and downs that researchers experience. When these exchanges are limited to only some participants, everyone within that setting (students, postdocs, faculty, and staff) loses. Each relationship that is lost, or never begun, is also a loss to the discipline as a whole. In addition, for URM students, who also often face discrimination and prejudice in nonwork settings, the exclusion and implicit devaluation within their graduate programs simply add to burdens that are already extraordinarily high.

This situation can be changed to create a more welcoming and inclusive environment. This will require self-awareness and careful attention by those in the majority to microaggressions and implicit biases, and sincere efforts to promote truly positive and supportive professional relationships. Many campuses have resources that can help individuals, research groups, and departments become more antiracist and inclusive, and models of successful efforts in STEM are increasingly available.[10−14]

Graduate students can also impact other issues by working together to address mutual concerns. It was clear from the extensive open-ended comments in the survey that students have many excellent suggestions for ways to improve graduate training. It was also apparent that some feared retribution if they raised concerns. Taking collective action through graduate student organizations and peer support groups could empower students to prompt change while also protecting vulnerable individuals. In addition, collective calls would likely receive more attention than those from individuals.

FACULTY

Our results highlight the key role of effective advising in promoting positive graduate experiences. Students with more supportive advisors were more likely to plan to complete their degree and to pursue a postdoc. Faculty should remember that the success of their students enhances their own reputations and future recruiting, while failures do not. Thus, we urge faculty to carefully examine relationships with their advisees. How often do they talk with their students? Are they providing the type of support, guidance, and feedback that their students want and need? Do they regularly assess the way in which their research teams are working? Are they fair and equitable? Are their students receiving the credit they deserve for their work? Are their students receiving adequate financial support?

Faculty also play a role in recruiting graduate students. The data described above indicate that the pool of potential PhD students who are women or identify as URM is relatively large. Individual faculty members could easily increase the number and diversity of PhD students by identifying, sponsoring, and mentoring promising students in these groups.

DEPARTMENTAL POLICIES AND PRACTICES

Departmental policies and procedures are extremely important in shaping graduate student experiences, and we believe that attention should be given to four important areas. First, departments should regularly assess student concerns and needs. At a minimum, such assessments should examine academic, interpersonal, and financial support. They should be designed to preserve student confidentiality and be accompanied by a commitment to use the results to address identified problems.

Second, departments should establish and maintain policies and programs that help ensure a more supportive and effective graduate education. Department leadership should make clear that graduate student success is a key element of faculty success and the reputation of a department. Training could be instituted to help faculty learn how to be better advisors and mentors. Exceptional advisors and mentors could be rewarded, while those who are negligent could be sanctioned. Chemistry is not alone in facing these issues, and much could potentially be learned from practices in not just our field, but also in other STEM disciplines.[10−14]

Third, necessary changes may require careful and open assessment of departmental culture and practices. It was clear from our analyses of students' comments that many feel unrecognized and exploited. They also face many demands and concerns that may not be recognized by faculty, such as harassment from peers or faculty, financial constraints, and mental health crises. From our quantitative analyses, we know that student concerns are more common in the most competitive and resource-rich departments. All departments, and perhaps especially those that are most highly ranked, could be well-served by reflecting on the way in which departmental environments, values, and priorities affect students and the future of the discipline.

Finally, our data suggest that the demographic composition of the faculty and student body influences graduate student experiences and plans. Students reported higher-quality advising in departments with a higher proportion of women.[8] Students who identified as URMs were more likely to aspire to postdocs and professorships in research universities when their faculties included at least one person who also identified as a URM.[8] Students at minority-serving institutions, both those who did and who did not identify as URM, were more likely than other students to definitely plan to finish their degrees.[9] These findings underline the importance of building both diverse faculties and student bodies.

PROFESSIONAL ORGANIZATIONS AND FUNDING AGENCIES

Meaningful change within individual departments will be much more likely to occur with support and facilitation by professional organizations and funding agencies. Concerns about financial support were widespread among the students surveyed. Many noted their low level of compensation, with hourly wages similar to or even less than those of fast-food workers. Many also noted the lack of adequate health care coverage and costs of ancillary services and fees from parking and transit to "technology" or other "extras". We suggest that funding agencies, which provide the bulk of support for research in chemistry departments throughout the nation, could lead efforts to address the financial strain of graduate education. Especially in light of current national policy discussions about increasing the minimum wage, funding agencies could set appropriate standards for student compensation including salaries and ancillary benefits.

One of the most disturbing findings of our analysis was the extent to which students in the later years of their programs

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who identified as URMs were less likely to receive financial support through "official" sources and more likely to rely on personal resources including loans. While our data were cross-sectional, rather than longitudinal, this pattern raises the possibility that the URM students might be recipients of some type of "teaser" fellowship in which they were enticed to begin their graduate career with special first-year recruitment incentives. Then, in subsequent years, as this funding diminished, they turned to personal resources and built greater debt. The result is a classic "Catch-22", requiring students to choose between not completing their degree and mounting debt that would follow them for years. Funding agencies could take the lead in calling for multiyear fellowships and documenting institutional practices that might underlie the pattern discerned in our data.

Professional organizations, such as ACS, could also lead change by systematically gathering and disseminating meaningful data on masters and PhD programs, similar to that in the life sciences.[15] Data such as admissions, matriculation, time to degree, completion rate, and career outcomes are highly informative for prospective students and can serve as an incentive for improvement for graduate programs. The ACS could also formally reward departments that provide exemplary support for graduate students. Finally, the ACS should be commended for commissioning the survey that was the basis of our analysis and its ongoing concern with graduate education.[16] We encourage the ACS to continue this work by establishing a formal task force to review the concerns of graduate students, with special attention to the documented inequities, and propose concrete solutions.

CONCLUSION

We present these comments in the firm belief that supportive and equitable graduate programs benefit all within the chemistry profession and advance the discipline's ability to innovate in response to national and global challenges, a belief that echoes official statements of ACS and other scientific groups.[16,17] It is important to note that our proposed changes have wide-ranging benefits. While our statistical results indicate that women and those who identify as URMs are more likely than others to have negative experiences, both the quantitative analysis and our extensive analyses of student comments indicate that these differences are simply a matter of degree. Many chemistry graduate students believe that their experience is less supportive than they desire. Thus, all students would benefit from improvements. Faculty and departments would also profit, as their reputations are directly tied to the success of their students. Leadership by the ACS and funding agencies can further accelerate change in the chemistry graduate education experience.

AUTHOR INFORMATION

Corresponding Author

Jean Stockard − *University of Oregon, Eugene, Oregon 97403, United States;* orcid.org/0000-0001-6134-7233; Email: jeans@uoregon.edu

Authors

Celeste M. Rohlfing − *University of Oregon, Eugene, Oregon 97403, United States*

Geraldine L. Richmond − *University of Oregon, Eugene, Oregon 97403, United States;* orcid.org/0000-0003-0876-5262

Maya Noviski − *University of Oregon, Eugene, Oregon 97403, United States*

Priscilla Lewis − *University of Oregon, Eugene, Oregon 97403, United States*

Complete contact information is available at: https://pubs.acs.org/10.1021/acs.jchemed.1c00611

Notes

The authors declare no competing financial interest.

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