Promoting Inclusivity and Collegiality: Advice from Students*

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Promoting Inclusivity and Collegiality: Advice from Students

Thank you for inviting me to be here today. It is an honor to be here and to learn more about your fascinating work. And I very much appreciate the opportunity to tell you a little about what I and my colleagues have learned about the lives of graduate students in the chemical sciences. I'm especially honored because I am not a chemist, but a social scientist, and appreciate that you would be willing to listen to some of our insights. I am also grateful that it is fine to share results of work in progress

Today I want to tell you about findings from analyses of three surveys of graduate students in the chemical sciences distributed by the American Chemical Society: one in 2013, another in 2019, and another in 2022, as the pandemic was waning. I am very grateful to the ACS for allowing us to have access to the 2013 and 2019 data and in collaborating with us in gathering the 2022 data. While we have published results of the 2013 analysis, we have not yet published those from the two later surveys.

My comments will focus on what we have found to date regarding students' career plans and graduate experiences and, especially, how these may have changed over the last 10 years. Our analyses have been guided by theoretical understandings from the social sciences regarding the ways in which individual backgrounds and environments influence aspirations, experiences, and views of the world. Thus, we have conducted extensive quantitative analyses that control for both individual characteristics and departmental and community environments. I'll describe the overall picture of how things have – or haven't – changed over time and the ways in which students' backgrounds, their experiences within their departments, and the nature of their departments might help explain differences in their plans and outlooks. While we have also examined students' comments regarding their experiences, most of what I will present today is based on quantitative analyses. I would be very happy to share written reports with any who are interested. After presenting the data I will reflect on the findings and implications that they might have for ensuring the well-being of graduate students and, by extension, the future of the profession.

Characteristics of the Students

The vast majority of respondents to the surveys were in PhD programs, and the results I'll present will be limited to students at that level, a total of almost 5,000 students. The samples are believed to represent the national pool of graduate students. They include a wide variety of schools, both private and public, from throughout the country. While the respondents came from more than 200 departments, the majority of students were from the more highly ranked departments in large public universities, simply because those schools have more students. The students were generally young. In the 2013 and 2019 surveys three-fourths of the first year students were 25 years old or younger. The median age, overall was only 26. This point is important for we know that historical events experienced in the young adult years can have especially momentous impacts on individuals' well-being. That is, people in this age range are more affected, throughout their lives, by such events.

There were some differences in demographic characteristics of students across the three years. (See Figure 1.) Compared to 2013 and 2019, the 2022 sample included significantly more women and those who identified with a racial-ethnic group traditionally under-represented (i.e., underrepresented minority (URM)) in the field, but significantly fewer students who were U.S. citizens or permanent residents. Importantly, these variables were controlled in the multivariate analyses of changes in students' plans over time.

The Impact of the Pandemic

In the 2022 survey we asked students about the personal impact of the pandemic. The vast majority of students (94%) indicated that they had experienced at least one personal negative impact from the pandemic. Most common were mental health issues, followed by increased financial concerns. (See Figure 2.)

Just as, if not more concerning was the finding that the increased personal strains had not diminished significantly by the time of the survey. Almost two-thirds of the students who reported financial concerns indicated that these concerns have worsened. Over two-fifths of those who reported issues with mental or physical health reported that these issues had become more problematic. For each area questioned, only a minority of students indicated that the concerns had diminished to pre-pandemic levels (the bar omitted from the graph). (See

Figure 3.) Multivariate analyses indicated that, when other variables were equalized, students who identified as URM or LGBTQ and students in large public universities reported more severe and continuing personal impacts of the pandemic. U.S. citizens or permanent residents reported fewer personal challenges.

Changing Career and Educational Plans

Clearly the students in the 2022 survey have had vastly different experiences in the time they entered and were in graduate school than those in earlier surveys. I want to look now at how their future educational and career plans might differ. And also, relying especially on the data from 2013 and 2019, on the extent to which students' demographic backgrounds, graduate school experiences and departmental context might influence future plans. I have summarized the results into graphs, but would be very happy to share the underlying statistical analyses. I will report briefly on 7 areas – academic specialty, preferred career sector, intention to stay in the chemical sciences upon graduation, probability of finishing the degree, plans to pursue a post-doc, adequacy of financial support, and problems encountered during the graduate program. I will then discuss some implications of the findings.

Field of Interest

Over time, there were some slight, but significant, changes in students' fields of interest. To enhance the validity of results my analysis focused only on the fields that were most commonly chosen, and results are shown in Figure 4. Students in the 2022, post-COVID sample were significantly more likely to report an interest in analytic, chemical biology, and material chemistry, but less likely to indicate an interest in inorganic. There was no clear pattern of change in interest in physical chemistry. Multivariate analyses indicated relatively few differences in these patterns across students with varying demographic or departmental characteristics. In other words, these changes seemed to be across the board – or at least not explained by the variables I introduced.

Sector of Employment

There were also changes in the preferred sector of employment. (See Figure 5.) Students in the 2022, post-COVID sample were significantly more likely than students in the 2019 sample to plan a career in industry and less likely to plan to enter academe. (The question

in 2013 was not directly comparable, precluding valid comparisons.) Multivariate analyses indicated that the declining interest in academe could not be explained by the various individual and department-related variables that were examined. That is, as with changing fields of specialization, the decreased interest in academe seems to be across the board. In contrast, the increased interest in industry was significantly stronger among students in the top-ranked schools.

Staying in the chemical sciences

The majority of students (71%) who responded to the 2022 survey believed that their career would be negatively affected by the pandemic, but, interestingly, there was no decline over time in students' commitment to the field. In all three survey years (2012, 2019, and 2022), around two-fifths of the students indicated that they were extremely likely to remain in the field and about the same proportion indicated that they were very likely to do so.

However, some students were less likely than others to plan to stay in the field. Multivariate analyses indicate that students who were more advanced in their programs or were in higher ranked schools were less confident that they would stay in the field. From the 2013 and 2019 data we have information on the relationship students have with their advisors, and this is far more important than other variables. Students who reported a more supportive and productive relationship with their advisor were much more likely to be confident that they would stay in the field.

Figure 7 depicts that relationship. The "good" advisors are those who were, on average across 19 different items, rated by students at 4 or higher on a 5 point scale. Those classified as "poor" were rated, on average, below the midpoint (i.e. less than 3.0). Overall over a fifth (22%) of the students were in this bottom group, while over a third (35%) were in the top group. That is, the "poor" advisors are a substantial subset of all advisors. The only group in which over half of the students definitely plan to stay in the field are those with good relationships with their advisors. Independently of the advisor-student relationship, students were significantly less likely to believe they would stay in the field if they were more advanced in their programs or in more highly ranked departments, as well as, in 2022, had suffered more severe personal impacts of the pandemic.

Finishing the Degree

While there appears to have been little change, overall, in the probability that students will stay in the chemical sciences, the data indicate a strong decline in the probability that students will finish their degree. (See Figure 8.) In 2013, over three-fourths of the doctoral students indicated that they would definitely complete their degree, but by the fall of 2022, only a little more than half did so. The change was greatest among students in the second to fourth years of their graduate program.

From the 2013 and 2019 data, we found that the most important factor associated with the probability of degree completion is students' relationships with their advisor. Over 80% of students with a good relationship believe they will definitely complete their degree, but less than two-thirds of those with a poor relationship believe this. (See Figure 9.) Independently, and at smaller levels of significance, students who were more advanced in their programs, older, or from countries other than the U.S. were more likely to plan to complete their degree. Women, and especially those who did not identify as an under-represented minority, were less likely to do so. There was no association of plans to complete with departmental rank, with the general level of support students felt from others in their departments nor with the rated adequacy of their funding. However, further analyses of the 2022 data indicated that students were significantly less likely to definitely plan to complete their degree if they had experienced more severe personal impacts of the pandemic.

Post-Doc Plans

Analyses also indicated significant declines over time in the percentage of students planning to pursue a post-doc, but that the pattern of change varied across students at different stages in their graduate program. (See Figure 10.) There was little change over time in first year students' plans for a post-doc. The decline for those near the end of their program was larger from 2012 to 2019 than from 2019 to 2022, while the decline for those in mid-program occurred consistently throughout the time period examined.

Paralleling the results with other variables, advisor support was very important in plans to pursue a postdoc, with those with more supportive advisors significantly more likely to do so. (See Figure 11.) In addition, and importantly, students who were U.S. citizens or permanent

residents were significantly less likely than others to plan to do a postdoc. In contrast to other analyses, students' post-doc plans were not related to the reported personal impact of COVID on their lives.

Financial Support for URM Students

One of the most disturbing findings from our work has been the extent to which difficulties with financial support are more often reported by students who identify with racial-ethnic groups that have been traditionally underrepresented in the chemical sciences. These differences are highly significant and remain with controls for the rank of the department and a range of other variables. As you no doubt know "rank" is determined by funding that departments receive for research. Thus the top-ranked departments have more resources to support students. Unfortunately, these resources may not be evenly distributed. Figure 12 shows the percentage of students who reported financial concerns during the pandemic for students in the top 25 departments, other ranked departments, and the non-ranked schools. The differences are stark. In the top-ranked, best-resourced departments, almost three-fourths of the students who identified as URM reported increased financial concerns during the pandemic compared to less than two-fifths of the non-URM students.

These differences appeared in the data gathered in earlier years. The 2013 and 2019 surveys asked students about the extent to which their funding was "adequate to meet the cost of living where they lived." Figure 13 shows the percentage of students indicating that their support was NOT adequate, paralleling the structure of the previous slide. In all groups of departments, students who identified as URM were more likely to report that their funding was inadequate. Disturbingly, paralleling the results in Figure 12, the gap was greater in the most highly ranked, resource rich departments, where 15% of the non-URM students but 28% of the students who identified as URM indicated inadequate funding.

I should also note that reports of inadequate funding increased over time. However, the increased concern was greater for students who identified as URM than for other students. In analyses of the 2013 data we found that students who identified as URM had funding equivalent to other students when they were in their first year of graduate school. However, by

2019, this pattern had disappeared and the disparity appeared for students at each year of their graduate program.

Problems and Harassment

Both the 2013 and 2019 surveys asked students if they had experienced "any problems directly related to your graduate program" In 2013, 16% of the students responded "yes," and in 2019 27% did so – a significant increase. Students in 2019 were also asked if they had experienced sexual harassment and other types of harassment, using the language defined by the Equal Employment Opportunity Commission (EEOC) including national origin, color, age, disability. Sixteen percent of the women and 8% of the men reported sexual harassment. Twenty percent of students who identified as URM reported general harassment, as did 15% of other students. This doesn't seem to be limited to a few "chronic complainers." In total, almost 40% of the students reported experiencing a problem with their graduate program and or harassment. Women were more likely to report harassment. Students who were more advanced in their program were more likely to report both having encountered problems and harassment. But, paralleling other results, students with more supportive advisors and with adequate funding were less likely to indicate having encountered these issues.

Disturbing Trends

Figure 14 summarizes some of the data presented above by examining the percentage of students who definitely plan to complete their degree, to stay in the chemical sciences, *and* to do a post-doc. This group could be seen as including students who hope to be the "high flyers" within the field and future leaders in, perhaps especially, the academic sector. Over all this percentage declined over the last decade: from 18% in 2013 to 13% in 2022. But the pattern of change differed by gender and between domestic students, defined as U.S. citizens and permanent residents, and students from other countries. The drop was much greater for domestic students and especially for women. In the 2022 sample only 12% of domestic men and 8% of domestic women indicated that they would definitely complete their PhD, stay in the chemical sciences, and pursue a post-doc. These data could be indicating a serious decline in the potential pool of highly trained and committed chemical scientists in the United States, with potentially serious implications for the field and the nation.

One possible bright spot within this trend involves the plans of domestic students who identify as an under-represented minority (URM). As shown in Figure 15, among U.S. citizens and permanent residents, students who identified as URM were significantly more likely to be highly committed to the field and there was little change in this pattern over time. As a result, it is likely that the pool of "high flyers" will become more diverse within the future.

However, the data also suggest that this high commitment could be associated with severe personal costs. Recall that students who identify as URM are far more likely to have experienced financial hardships during the pandemic and continuing (Figure 12). They are also significantly less likely to have funding that is adequate to meet the cost of living, and this trend became more serious over time (Figure 13). In addition, as noted above, students who identify as URM are significantly more likely to face harassment and problems in their graduate program. It is difficult to articulate the extent to which their commitment to the field involves extraordinary courage and resilience as they face both heavy financial demands and the toll of dealing with difficult interactions and situations not encountered by their peers.

Reflections

As I pulled together the data for this presentation I found myself worrying about the future of graduate education in the chemical sciences. Can the current situation continue? Most students plan to continue within the chemical sciences in some capacity, and there has been little change from previous years. Yet, there have been disturbing declines in students' expectations that they will finish their PhDs or pursue a post-doc. Many face issues with funding. Quite disturbingly, the financial concerns are markedly greater for students who identify as an under-represented minority and are strong in even the departments with the greatest amount of research funding. Substantial proportions of students report encountering problems in their graduate programs and experiencing harassment. While having a supportive advisor helps minimize these difficulties, only a minority of students have such support. Interestingly, in our analysis of the qualitative data from the 2013 survey, virtually all students, no matter how they ranked their individual advisor, seemed aware and concerned with the environment and actions within their departments.

It is clear that the pandemic has made the situation worse. It is also clear that students who faced more serious personal impacts of the pandemic report more concerns regarding their future career and doubts about their educational future. Yet, many of the disturbing trends began before the pandemic. In addition, it is important to remember that the impact of the pandemic could be long-lasting and that the majority of students are at an age where they might be particularly vulnerable to its impact.

In short, the data appear to indicate a very sobering situation and one that is not improving. Individual students' decisions to opt out of the "high flyer" type of educational trajectory may be quite rational. One can certainly understand decisions to leave an environment that is reported as unsupportive and problematic. Yet, on an aggregate, or societal, level, the trends described could indicate the possibility of a declining pool of highly trained chemical scientists. This trend could be seen as especially serious given the myriad issues faced by our society and the world at this point in history. Thus it seems imperative to ask why this situation has occurred. I would hypothesize that one possible factor could involve the structure and culture of the discipline and graduate programs.

There is a basic sociological truism, grossly stated, that there aren't bad people but dysfunctional or "bad" social structures and cultures. I would hypothesize that the patterns described in my graphs and comments stem from the system of social roles, expectations, and norms that are embedded within the discipline and the graduate school environment. Faculty are faced with extraordinary pressure to obtain grants and publish. University regulations and the practices of funding agencies limit the support that can be given to students. Most faculty entered the profession through this system and may not be able to even envisage an alternative. Students may simply accept this as the way it must be and see no alternative if they wish to adhere to this career path.

There are several elements within the data that support my suggestion that the problems reflect cultural patterns. Students' reports of department culture and advisor behavior did not vary over time. They were also no differences in advisor behavior between male or female advisors or when students had advisors that were of the same gender or not. Over time, as more women and minorities have entered graduate school, disparities related to

gender or minority status have declined, suggesting that all students are treated equally well (or badly). As noted earlier, comments from students indicate that even those who have relatively good experiences within graduate school understand the issues that face their departments and the field.

But we must remember that social structures and cultures are human creations. People built them and, through our actions, we reproduce them. Thus, we can also change them. Actors throughout the system can promote change. I don't have time to go into the various elements and aspects of such endeavors, and have written about this elsewhere. But, as detailed in those writings, I believe that students, faculty, administrators, staff, funding agencies, and professional organizations can all have a role. In their own way, each of these groups possesses a power and influence; and, through collective action, they can press for meaningful change.

Given the data that I've presented it would seem to me, an outsider, that such change is important. And it is important on several levels: If the discipline is to advance it is crucial that a pipeline of new talent be accepting and wide. The nation, and the world, needs a workforce in the chemical sciences that includes as much of the available talent as possible. And, on simple human terms, we want that work force, and the students who aspire to it, to be in environments that are healthy and supportive. That will produce the best outcomes. I hope that you will be able to help lead those changes.

Figure 1: Demographic Characteristics of Respondents, 2013, 2019 and 2022

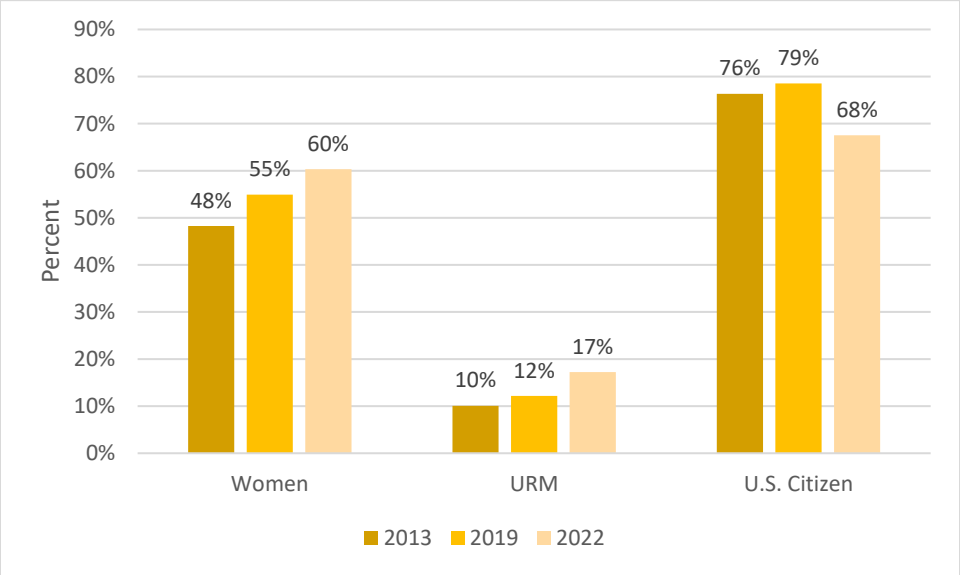

Figure 2: Percent of Students Experiencing a Negative Impact of the Pandemic, by Type of Impact

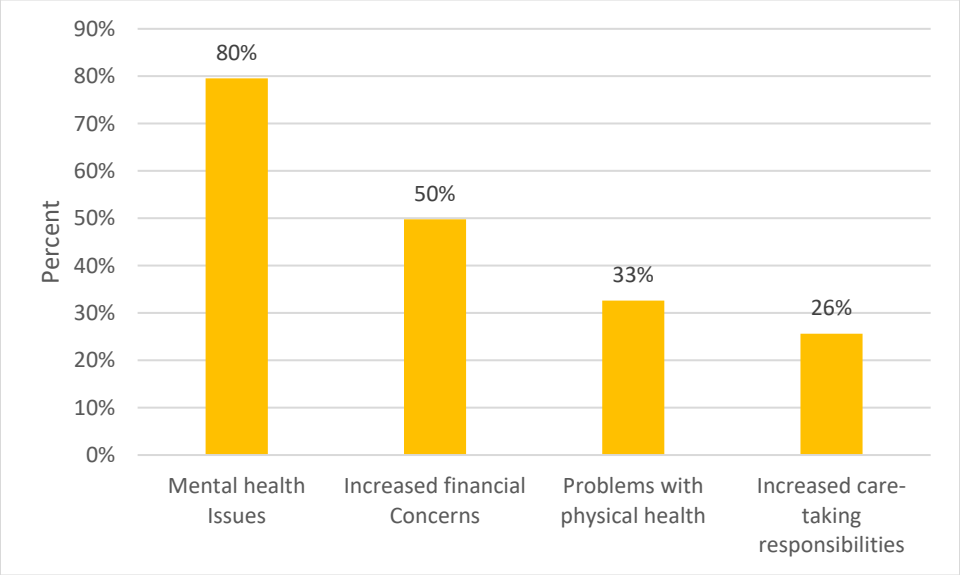

Figure 3: Changes, as of Fall 2022, in Negative Personal Impacts of the Pandemic

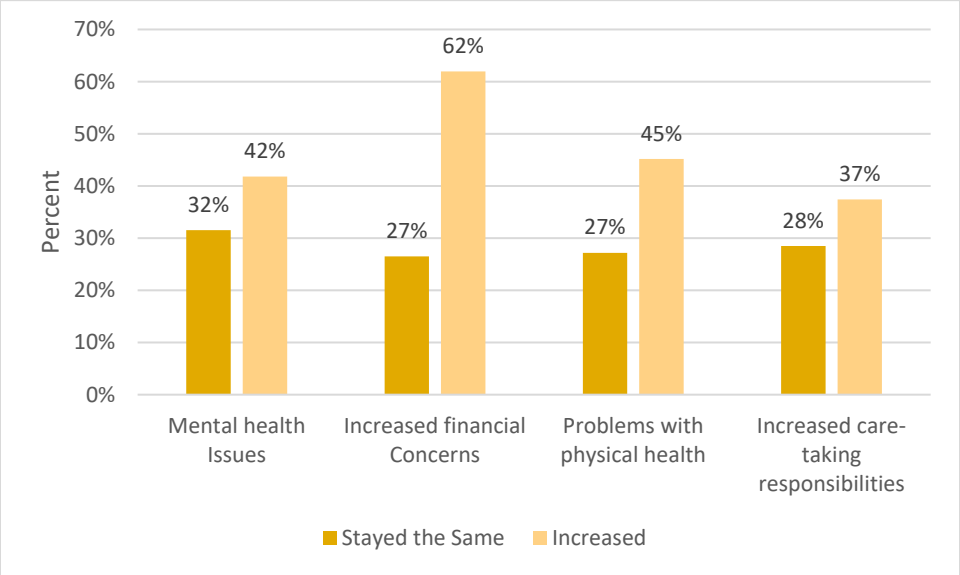

Figure 4: Field of Interest, PhD Students in Chemical Sciences, 2013, 2019, and 2022

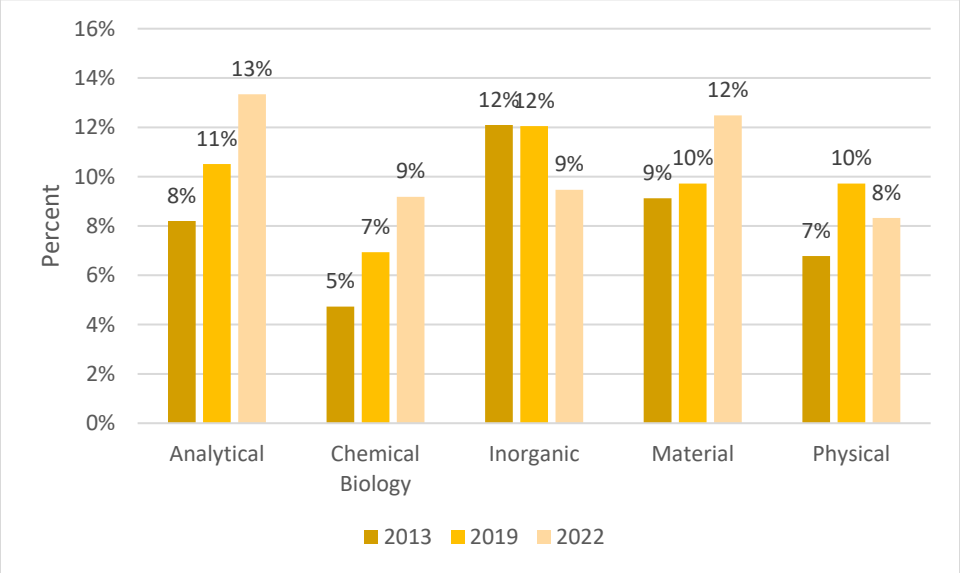

Figure 5: Career Sector of Interest, 2019 and 2022

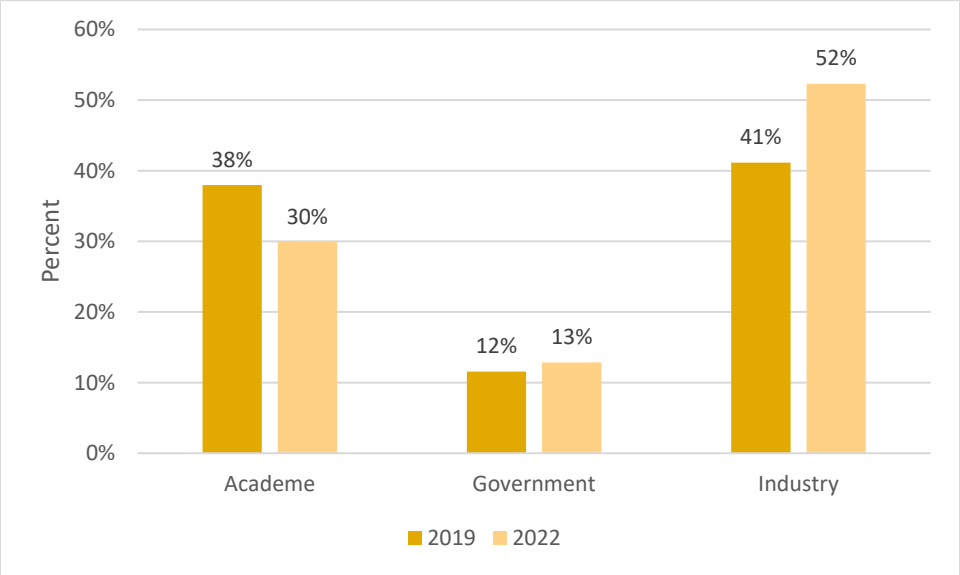

Figure 6: Likelihood of Students Staying in Chemical Sciences, 2013, 2019, and 2022

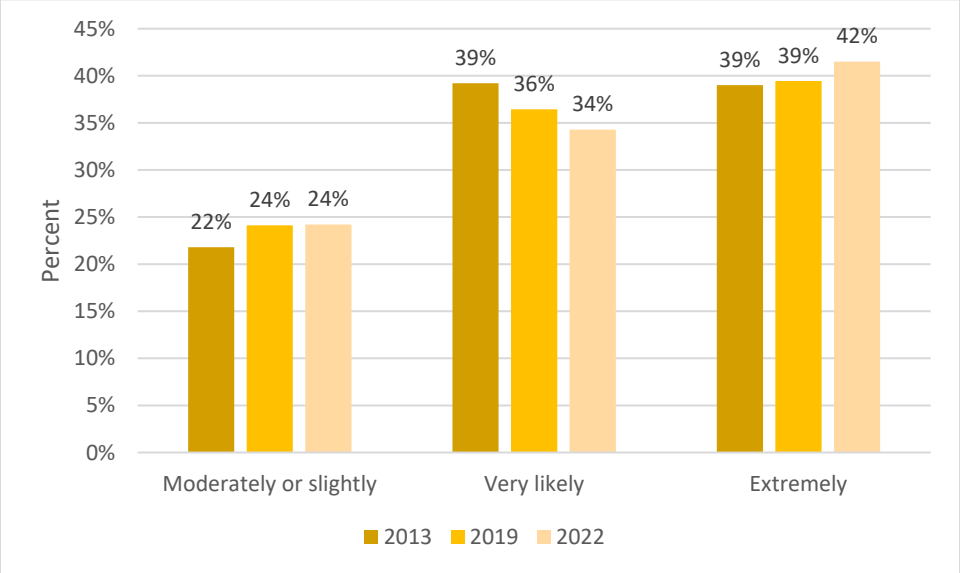

Figure 7: Plans to Stay in Chemical Sciences by Quality of Advisor-Student Relationship

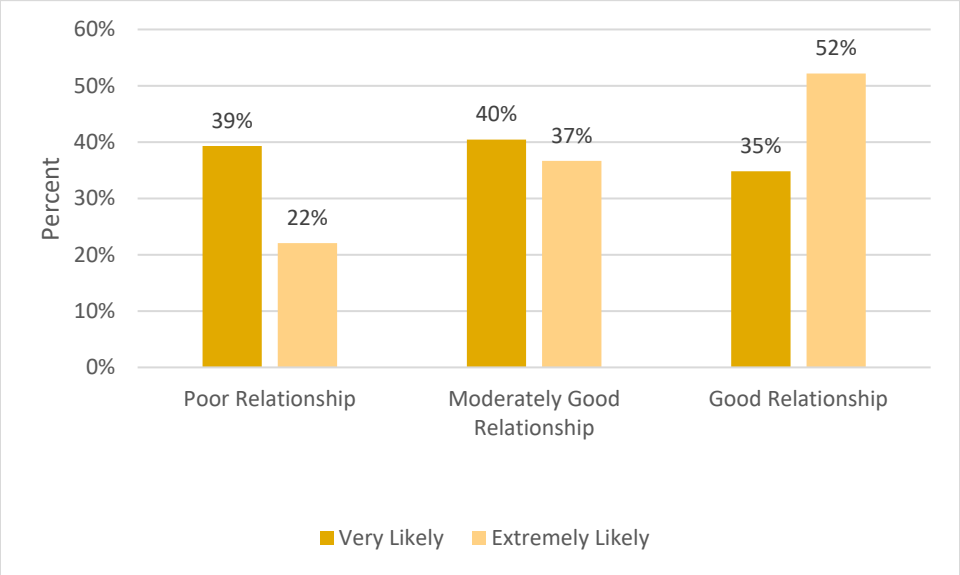

Figure 8: Percentage of Doctoral Students Definitely Planning to Complete Degree by Year in Program, 2013, 2019 and 2022

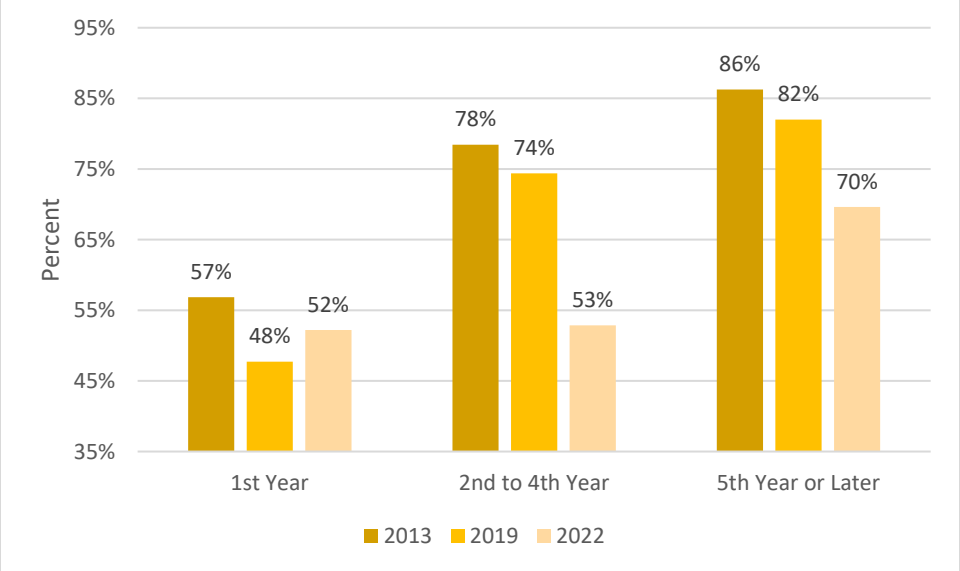

Figure 9: Percent of Doctoral Students Definitely Planning to Complete their Degree by Quality of Relationship with Advisor, 2013 and 2019

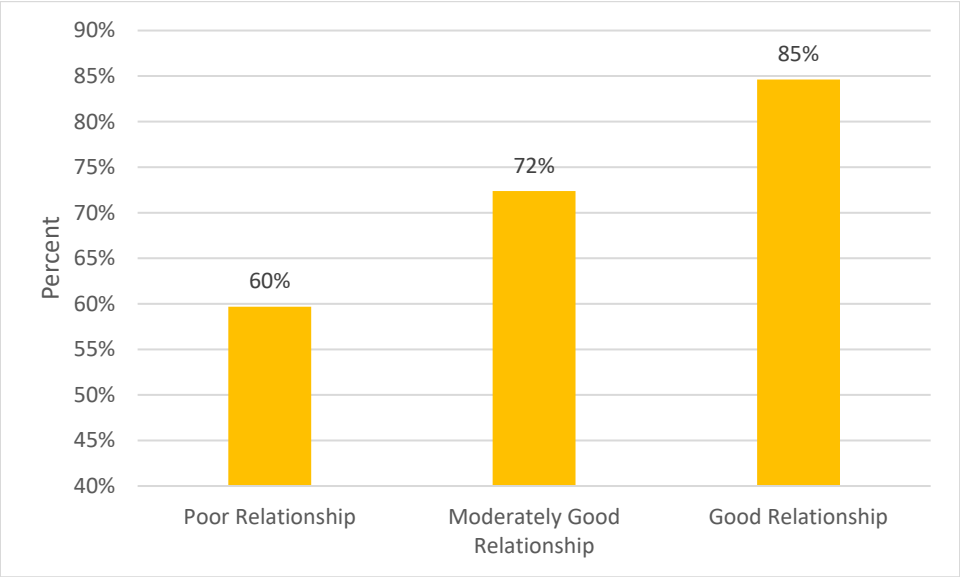

Figure 10: Percentage of PhD Students Planning to Pursue a Post-Doc by Year in Program, 2013, 2019, and 2022

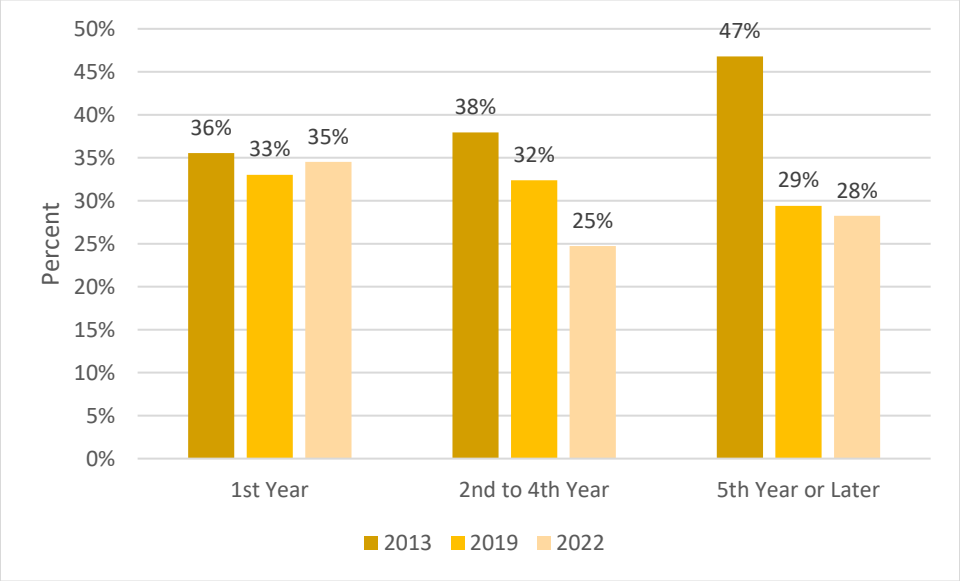

Figure 11: Percentage of Students Planning a Post-Doc by Relationship with Advisor

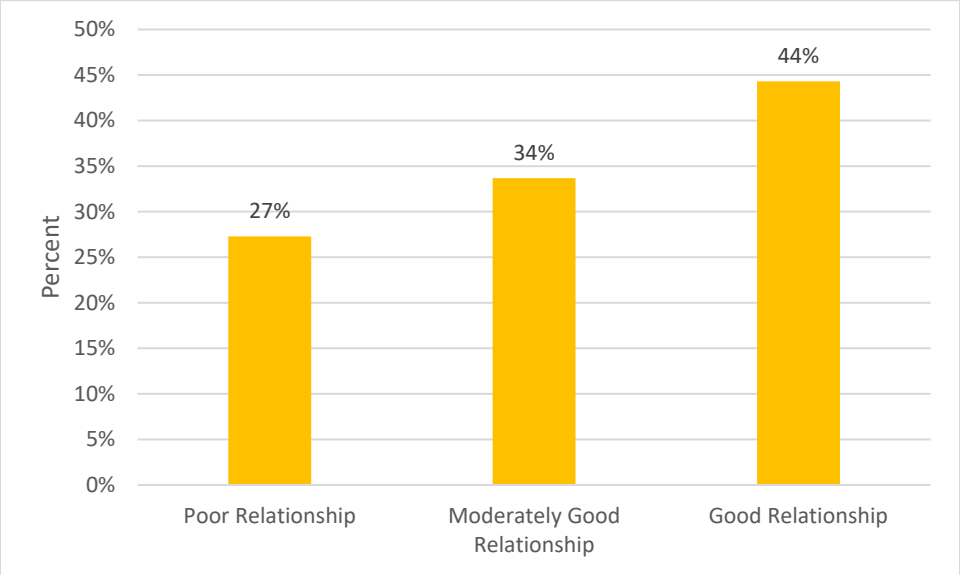

Figure 12: Percent Experiencing Increased Financial Concerns during the Pandemic by Identification as URM and Rank of Department

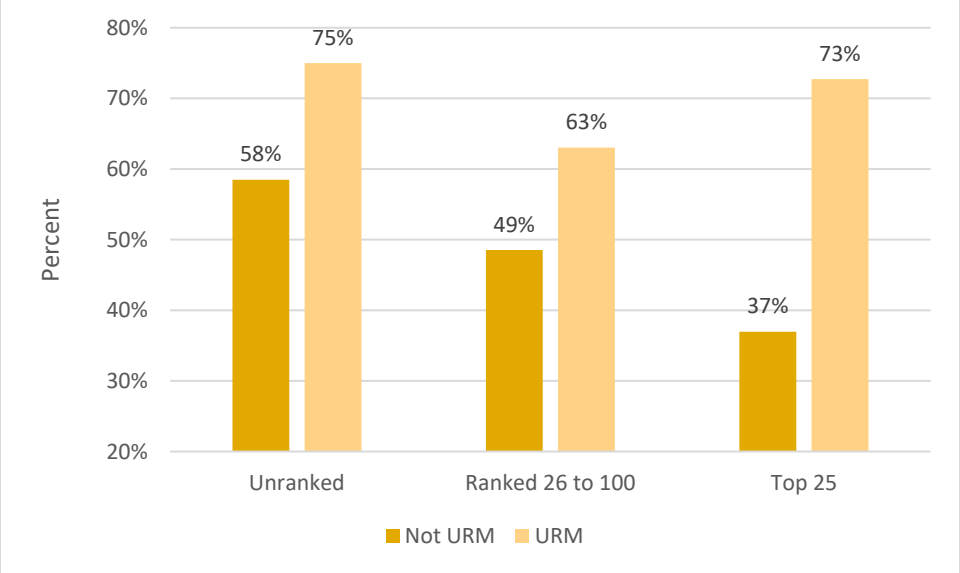

Figure 13: Percent Students Indicating Funding is NOT Adequate for Cost of Living by Identification as URM and Rank of Department, 2013 and 2019

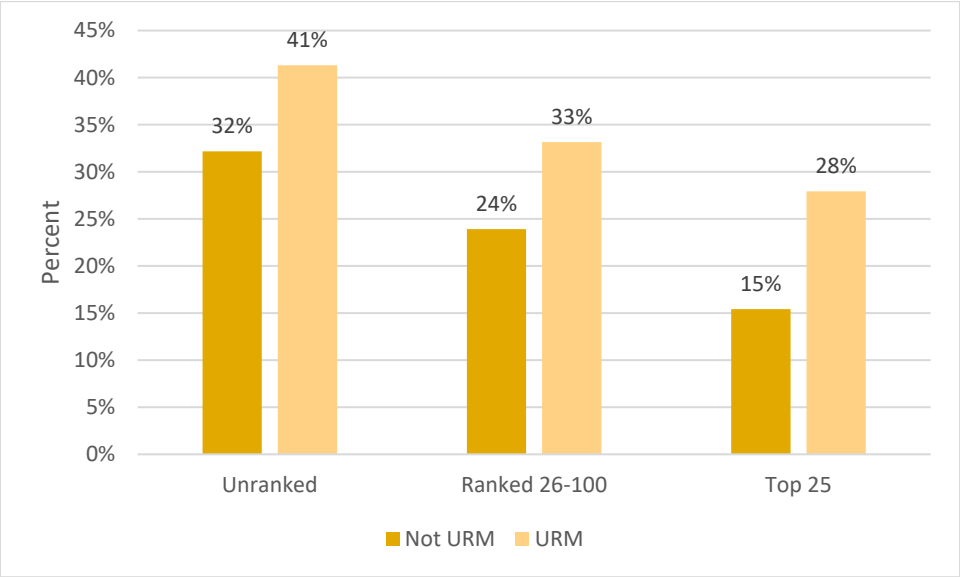

Figure 14: Percent of Students Highly Committed by Year, Gender, and Permanent Residence

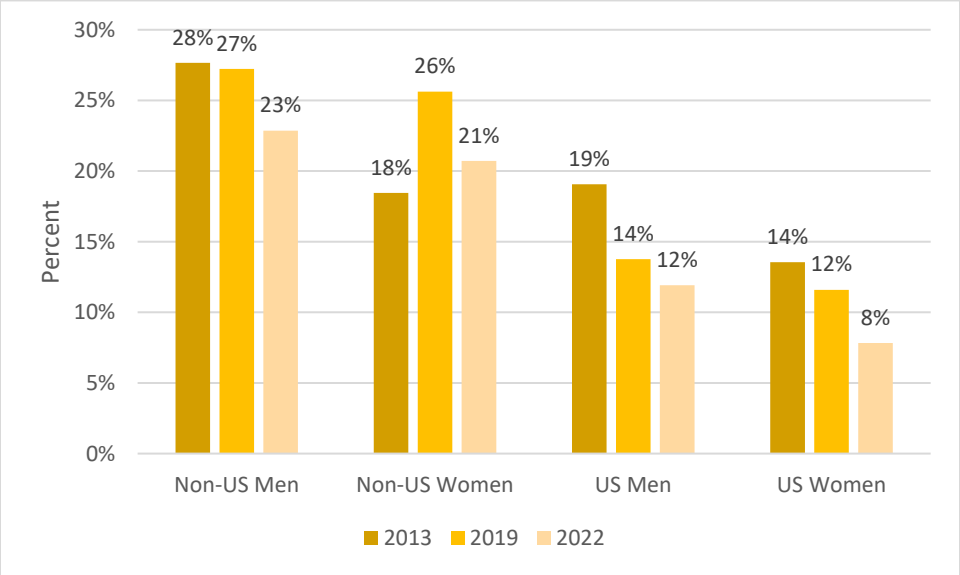

Figure 15: Percent U.S. Students Highly Committed by Year and Identification as URM