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2019 ACS Graduate Student Survey Report

ACS EDUCATION | Student & Postdoctoral Scholars Office
American Chemical Society

About This Report

The 2019 ACS Graduate Student Survey was created through the support of the Education Division and its Student & Postdoctoral Scholars Office (SPO) at the American Chemical Society (ACS). ACS SPO supports undergraduate and graduate students as well as the postdoctoral scientific community in the chemical sciences by creating relevant career and professional development resources. The results of the 2019 ACS Graduate Student Survey are expected to help chemical science departments to design local programming, allocate resources, support infrastructure that address the needs of trainees, and inform federal agencies about community needs.

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The American Chemical Society greatly appreciates the thoughtful responses provided by the graduate students who participated in this survey. ACS sincerely hopes that this survey provides you with a voice in helping to create the future of chemical sciences graduate education in the United States.

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2019 ACS GRADUATE STUDENT SURVEY EXECUTIVE SUMMARY

The American Chemical Society (ACS) Student & Postdoctoral Scholars Office conducted a survey of graduate students in the chemical sciences between May and October of 2019. A total of 2,772 usable responses were received; of these, 2,534 (91%) were from doctoral degree students and 238 (9%) were from master's degree students. The survey consisted of 43 questions that focused on career interests and plans, graduate education competencies, and contextual factors such as advisors and mentors, resources, support, and satisfaction.

Key Findings of the 2019 ACS Graduate Student Survey

Career Interests and Plans

- Students at both the master's and doctoral degree levels were most interested in careers in industry. Doctoral degree-level students indicated they were most interested in academic careers at the start of their graduate studies.
- Graduate students at both the master's and doctoral degree levels feel that they have a limited knowledge of nonacademic careers.
- Career choices of graduate students are mostly influenced by their motivation to find work/life balance and their self-awareness. There is a notable difference between how various racial and ethnic groups tend to rate the importance of values in contributing to career decisions.
- The majority of graduate students feel the best time to learn about career areas and opportunities for graduate degree holders is before starting graduate school.
- The majority of graduate students rate search engines (e.g., Google) and professional conferences as the most useful career resources they use.

Graduate Education Competencies

- Majority of master's and doctoral degree students believe they are proficient in the core competency areas described by the National Academies Press report on *Graduate STEM Education for the 21st Century* (2018).¹

Social/Contextual Factors

- Positive characteristic behaviors that students cited as descriptive of their research advisor center around providing an appropriate level of research independence and recognition (e.g., "encourages me to gain independence over the course of my graduate studies," and "gives the appropriate level of credit to me for my research contributions").
- Positive characteristic behaviors that students cited as less descriptive of their research advisor center around providing career path support and advice and taking a personal interest in them.
- Female research advisors, in comparison to male advisors, are perceived by graduate students as being more likely to encourage their students' engagement in professional development opportunities (e.g., writing grant proposals, presenting at conferences).
- Sixty-five percent of students reported that their advisor created an environment where group members were treated fairly.
- Having experienced harassment during their graduate school experience was indicated by 11% of female and 5% of male graduate students.

Resources and Benefits

- Many students are either not aware of or do not use available campus resources and benefits (e.g., safety training, career counseling, job placement services, etc.) available to them.

International Experiences

- Graduate students who are U.S. citizens and permanent residents are more interested in or willing to engage in short-term (up to two weeks) than in long-term international research experiences.
- Students' main motivations for engaging in international research experiences center around "becoming more culturally aware" and "expanding my professional network."

Satisfaction

- Satisfaction with their overall graduate school experience was indicated by around 80% of doctoral and master's degree students.
- Among doctoral degree students, 68% indicated they would "definitely" complete their degree; 86% of master's degree students said the same. (Note: The calculated percentage for doctoral degree students in 2019 is 10% lower than the value calculated in 2013 Survey).
- Graduate students who identified as White were less likely than Asian and graduate students from underrepresented groups to respond that they "definitely will" complete their graduate degree.

The Recommendations Resulting From the 2019 ACS Graduate Student Survey Are:

- Conduct future surveys examining the values and socialization factors of graduate students in the chemical sciences that will provide a multicultural lens to focus on topics such as career motivation, advisor–advisee relationships, sense of belonging, intersectionality, and mentor–mentee relationships. These surveys have the potential to elucidate connections with socialization research done in other STEM and humanities fields, allowing for a convergence of cross-disciplines and of research, theory, and practice.
- Disseminate and share transparent, real-time information with undergraduate and graduate students about the wide variety of career paths available to chemical scientists with graduate degrees, including current job market data, expected competencies for various positions, and career outcome data of alumni and alumnae, members, and others with chemical science degrees.
- Promote the importance of and implement activities that achieve diversity, equity, inclusion, and respect (DEIR) for the students, faculty advisors, administrators, and staff within the graduate education community.
- Communicate the value and breadth of different career areas available to chemical scientists with master's and doctoral degrees, and provide programming that allows graduate students to explore different career areas and sectors. Ideally, the programming should be embedded in the curricula early in graduate students' experience.
- Communicate the value and expected core competencies associated with the acquisition of a graduate degree in the chemical sciences as described by the National Academies Press report on *Graduate STEM Education for the 21st Century* (2018).¹
- Enhance graduate curricula to provide guided competency development activities that address communication, project management, pedagogical, and leadership skills.
- Communicate the value of available benefits, including career counseling resources, to graduate students.
- Promote and provide guidance for the use of Individual Development Plans (IDPs) with an intentional focus on the flexible, adaptable, and iterative nature of the IDP process. Programming associated with the IDPs should allow for thorough self-assessment.
- Provide substantive resources to address and prevent harassment (e.g., related training for students and faculty, mechanisms that encourage dialogue and reporting, and supportive

structures for vulnerable groups, etc.). A code of conduct should be shared with the graduate education community. Clear guidelines for how to address behaviors associated with any kind of harassment and a commitment to accountability should be disseminated.

- Communicate the value of and provide access to experiential opportunities (e.g., internships, international research, teaching opportunities, broader impact opportunities, etc.) that can significantly enhance the personal and professional development of graduate students.

These recommendations are based on the findings of this survey within the contexts of recent reports on graduate education, the current job market climate, and potential collaborative endeavors among the stakeholders of the graduate education ecosystem (i.e., university and industry partners, department representatives, graduate student mentors and advisors, partner professional societies, graduate students, and ACS).

1. Introduction

Graduate students in the chemical sciences play a critical role in advancing research and innovation in the United States. Graduate education is an opportunity to acquire competencies that enable individuals to make meaningful and impactful contributions to all career areas.² In addition, graduate students who engage in research-based degree programs have the opportunity to advance knowledge for the progress of society. In the United States, about 5,500 students graduate with master's or doctoral degrees in chemistry each year.³

Many scholars and organizations have examined the state, impact, support systems, and career outcomes of STEM and biomedical graduate education.^{1,4,5,6,7,8,9} The goal of these efforts was to retain the U.S. STEM graduate education system's status as the gold standard for the global community and to allow graduates to develop impactful and meaningful careers. Recommendations for institutions included sharing local and national career outcomes with their students and faculty, building robust career and professional development programs, providing support infrastructure that diversifies the student community and enables inclusivity and equity in graduate education, and communicating core competencies that are acquired during the graduate school experience. Recommendations for funders included adjusting their program portfolios to maximize the educational experiences of STEM graduate students (e.g., funding sources for graduate students, mentoring, mental health, anti-harassment culture, and diversity).¹ Recommendations for professional societies included helping to build diverse, equitable, and inclusive environments, to facilitate conversations between employers and universities, and to support career and professional development initiatives.¹

The American Chemical Society's report on *Advancing Graduate Education in the Chemical Sciences* (2012)⁵ suggested that, as a community, it is pivotal for the chemical sciences to offer activities that would enhance students' ability to communicate complex topics to a variety of audiences in order to effectively influence decisions, their ability to collaborate on global teams, and their ability to understand the ethical conduct of research. This report recommended revisiting the financial support system of graduate students and focusing on adapting the best safety practices in academia. The *2013 ACS Graduate Student Survey Report's* recommendations included a closer collaboration of campus career centers with chemistry departments, support for developing written and oral communication skills, and making Individual Development Plans (IDPs) accessible to graduate students.⁴

Between 2013 and 2019, universities, funders, and professional societies from various disciplines have attempted to address many of the recommendations to help build an advanced graduate education system for career-ready students. In 2015, ACS developed ChemIDP.org, an online planning tool for chemical scientists that focuses on an iterative process of career exploration, self-assessment, skill-strengthening, and goal-setting. In 2018, ACS was awarded an NSF Innovation in Graduate Education¹⁰ grant, Impact Indicators and Instruments for Individual Development Plans (I3IDP), to evaluate IDP efficacy across different institutional IDP models and different outcomes. In addition, ACS developed the *Graduate & Postdoctoral Chemist* magazine (GPChemist.acs.org) that publishes articles about career advice and paths, wellness, lab life, awards, fellowships, and general topics related to grad student and postdoc life. *The ACS Career Kick-Start*er workshop, launched in 2019, was developed to provide departments with a two-day workshop to educate their students about various careers available to those with graduate degrees, as well as practical mechanisms to plan for their desired career paths. The ACS Bridge Project, in collaboration with the NSF INCLUDES Alliance: Inclusive Graduate Education Network, aims to broaden participation in graduate education. ACS publishes career and professional postcards that provide quick guidance about topics such as mentoring, the U.S. educational

system, and peer review in publishing. Updated publications such as *Six Steps to a Postdoctoral Position in the Chemical Sciences That Is Right for You*, and *Tips for Securing a Faculty Position* continue to support individuals who choose an academic career path.

Federal agencies such as the National Science Foundation (NSF) have established funding mechanisms that encourage the development and implementation of bold, new, and potentially transformative models for STEM graduate education training. The NSF Research Traineeship (NRT) Program¹¹ addresses workforce development, emphasizing broad participation and building institutional capacity to meet needs in graduate education; it issued its first awards in 2013. NSF programs such as the Graduate Research Internship Program (GRIP, 2014),¹² Graduate Research Opportunities Worldwide (GROW, 2013),¹³ International Research Experiences for Students (IRES),¹⁴ and Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (INCLUDES, 2016)¹⁵ have been established or updated to broaden experiences and participation in graduate education.

The Council of Graduate Schools has continued to publish significant work that helps inform academic and other programs aimed at the professional development of graduate students.^{16–18}

The National Academies of Sciences' Committee on Revitalizing Graduate STEM Education for the 21st Century recommended core competencies for masters' and doctoral degree students in STEM in 2018.¹ The report also recommended that graduate students should be able to select their graduate program aided by transparent, accessible data about associated costs, available career paths, and career outcomes of alumni and alumnae. Indeed, in recent years many academic graduate programs have started to track alumni and alumnae and to share program career outcomes with future and current students.

Over the last seven years, a plethora of new initiatives, programming, recommendations, and funding opportunities might have impacted how graduate students in the chemical sciences feel about the support they receive toward gaining their degree, their career path choice, and their workforce entry. A quickly changing job market has called for more social and analytical skills,¹⁹ adaptability, a global mindset, and career resilience.²⁰

The ACS Student & Postdoctoral Scholars Office, with the support of the ACS Graduate Education Advisory Board, conducted the 2019 ACS Graduate Student Survey to assess the graduate student experience from students' viewpoints. The responses are intended to highlight what is working well and identify opportunities for universities, departments, graduate programs, the ACS, funders, and other entities with a vested interest in graduate education in the chemical sciences to enhance retention, a sense of belonging, and the career preparation of students. We believe that this report can help contribute to a more positive and productive graduate student experience.

2. Methodology

Survey Design and Administration

The American Chemical Society conducted a survey of graduate students in the chemical sciences from May until October 2019. The survey consisted of 43 core questions and focused on career plans and preparation, graduate education competencies, student–advisor relationships, resource availability, satisfaction, and support mechanisms (the survey instrument is available in Appendix A, Survey Instrument; The survey and corresponding communications were reviewed by an Institutional Review Board [IRB] [Solutions IRB; reference number 2019/05/4]). The 2019 ACS Graduate Student Survey was created in and deployed through Qualtrics® and used branch logic.

The survey was delivered online. An email with a link to the survey, an introduction to the survey, and the IRB reference number was sent to department chairs in the chemical sciences (June 11, 2019) with the request to forward the survey to their graduate students. On July 17, 2019, corresponding survey information and the same request were shared through the ACS Faculty Newsletter. On October 7, 2019, an email was sent to 14,000+ ACS graduate student members drawn from the ACS database. Department chairs and ACS graduate student members received one reminder a month after the initial email.

To capture responses from additional graduate students who were not ACS members, the survey was promoted on Twitter and LinkedIn. As an incentive for participating in the survey, students were offered the chance to register to win one \$1,000 award in travel support to an ACS meeting or one out of ten gift certificates in the amount of \$100 each.

A total of 3,671 individuals responded to the survey. At the start of the survey, 288 respondents self-identified as non-graduate students in the chemical sciences and thus were excluded from analysis. We presume the non-graduate student responses occurred because the respondents' status changed since the last time they updated their ACS membership information or the respondents mistakenly went into the graduate student survey instead of the ACS postdoctoral scholars' survey. An additional 611 individuals did not continue the survey after the first question. Thus, the final sample for analysis includes 2,772 respondents, 238 (8.6%) of whom are current master's degree students and 2,534 (91.4%) of whom are current doctoral degree students.*

Table 1 (on page 11) presents key demographic characteristics of the ACS survey sample. The sample mainly includes doctoral degree students, and thus the trends in this report are mainly reflective of individuals in Ph.D. programs in the chemical sciences. For the gender distribution among respondents, females (55.2%) are represented more in the sample than males (41.6%). Additionally, a very small percentage of the sample identified as nonbinary/third gender (0.7%) and 0.5% and 2.0%, respectively, of the survey respondents preferred to be self-described or preferred not to say.

Differences between master's and doctoral degree student responses were tested for statistical significance on nearly all survey items (please see Appendix B, Additional Methodological Details, for further information.) Select tables in this report present data separately for master's and doctoral degree students; please see Appendix D, Disaggregated Characteristics of Survey Sample, for additional disaggregation of survey data by degree program. Moreover, data were disaggregated by gender on nearly all survey items in order to examine how female and male respondents differed in the sample and to aid in making inferences about the total population of graduate students in the chemical sciences. Responses from those identifying as nonbinary or third gender were not included in the difference-by-gender analysis because of the small sample size. Across all survey items, only those differences that reached statistical significance at $p < .05$ are discussed in this text. Select tables present data for female and male respondents separately. Appendix E, Supplemental Table, provides supplemental figures and tables.

*Due to attrition throughout the survey, the data analysis for each item was performed using the valid N for that item or group of items. Throughout this report, where "N" is listed, it represents the total population of an item (valid N), and "n" represents the sample size of a subgroup shown in the table. For questions that included multiple items to answer, the greatest number of responses out of all the items was reported for each subgroup. For example, if a table was reporting the responses from female respondents to a five-item question with 68, 64, 67, 63, 64 responses, respectively, then the "n" reported for female respondents would be 68. For questions that were not disaggregated by a demographic characteristic, the "N" reported is the greatest number of responses out of all the items.

Finally, throughout the report, select data are disaggregated by students' year in their degree program, underrepresented racial or ethnic groups † or citizenship status ‡ mentioned here. As with gender and degree program, differences among groups discussed in text reached statistical significance at $p < .05$. Tabular presentations of these data are available from the authors upon request.

Because of limited access to 2013 ACS Graduate Student Survey data, statistical analysis between the 2013 and 2019 survey results was not performed. All comparisons described in the text are general and do not represent statistical differences.

† For the purpose of this report and analysis, “underrepresented groups” consists of those students who identified as American Indian/Alaskan Native, Black/African American, and Native Hawaiian or other Pacific Islander ($n=99$, 5.5%). Those identifying as Latino/a or being of Hispanic origin were placed into the racial/ethnic category they identified, where applicable. The underrepresented group was compared, pairwise, to respondents identifying as White ($n=1,274$, 70.2%), Asian ($n=370$, 20.4%), and, for select questions, “other” ($n=72$, 4.0%).

‡ In disaggregating students by citizenship, students who identified as U.S. Citizens, Naturalized Citizens, and Permanent Residents were considered “domestic” ($n=1,495$, 79.1%), while those who identified as J-1, F-1, or H1-B visa holders were categorized as “international” ($n=379$, 20.0%). When comparing responses by citizenship/visa status, the respondents selecting “other visa” were excluded.

Table 1. Comparing the 2019 ACS Graduate Student Survey Sample with the Characteristics of the 2013 ACS Graduate Student Survey Sample and the National Population of Doctoral and Master’s Degree-Earners in Chemistry (5-year average, 2013–2017). Percentages are reported.

Current degree program	2019 ACS Graduate Student Survey sample (2,772)	2013 ACS Graduate Student Survey sample (2,992)	Master’s degree, national population* (2,495)	Doctoral degree, national population* (2,913)
Doctoral degree	91.4	92.0	---	---
Master’s degree	8.6	8.0	---	---
Gender (N=1,814)				
Female	55.2	49.0	45.1	39.4
Male	41.6	51.0	54.9	60.6
Nonbinary/third gender	0.7	---	---	---
Prefer to self-describe	0.5	---	---	---
Prefer not to say	2.0	---	---	---
Citizenship or visa status (N=1,891)				
U.S. native	74.0	71.1	---	---
U.S. naturalized citizens	2.8	3.5	---	---
U.S. permanent resident	2.3	2.1	---	---
Foreign student (F-1) visa	19.3	21.5	---	---
Other visa	1.7	1.9	---	---
Racial background (N=1,815, 2019 Survey)				
American Indian/Alaska Native	1.9	1.7	---	---
Asian American/Pacific Islander	20.7	23.7	---	---
Black/African American	3.3	3.9	---	---
Other	4.0	3.8	---	---
White	70.2	67.0	---	---
Of Hispanic/Latino/a descent[†]	6.3	5.8	---	---
Race/ethnicity among U.S. citizens/ permanent residents only[‡] (N=1,463)				
American Indian/Alaska Native	1.4	1.8	0.3	0.4
Asian American/Pacific Islander	8.3	8.0	11.9	9.5
Black/African American	2.5	3.5	5.7	4.4
Hispanic/Latino/a	6.5	5.7	7.7	5.9
Other	1.9	2.0	8.9	8.8
White	79.3	78.9	65.5	71.0

*Source: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations of U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Survey, average for 2013–2017.

[†] On the 2019 ACS Graduate Student Survey, the Hispanic/Latino/a question was asked separately from the race/ethnicity question. About 6% of all students responding to the question (N=1,872) marked that they were Hispanic/Latino/a. Of those

marking Hispanic/Latino/a, 87% marked an additional racial/ethnic category (the distribution was as follows: 57.8% White, 2.9% Black/African American, 12.7% American Indian/Alaskan Native, 2.9% Asian/Pacific Islander, and 23.5% other). ‡ The Hispanic/Latino/a category was merged with existing racial categories in this calculation. If a respondent marked Hispanic/Latino/a, the respondent was placed into this category regardless of other racial categories that the individual may have marked.

3. Results

The *2019 ACS Graduate Student Survey* solicited feedback from graduate students in three major areas: career interests and plans, graduate education competencies, and contextual factors, such as advisors and mentors, resources, support, and satisfaction. The following sections present the survey results in the context of these categories.

3.1. Career Interests and Plans

Students' rankings of career interests are reflected in Table 3.1.1, wherein industry (41.2%) and academia (38.0%) were by far the most likely to be highly ranked, followed by interest in government (11.6%), entrepreneurship (4.9%) and nonprofit (4.4%). Considering gender differences, female respondents (34.0%) were less likely than male ones (40.0%) to rank academia as a current top career interest. This downward trend was also true in the difference between the rankings of working in entrepreneurship for female (3.8%) versus male respondents (7.1%). Female respondents (14.1%) were also more likely than male ones (8.8%) to rank a government job as a top choice. There was little appreciable difference between the current top career interest rankings of doctoral degree graduate students versus master's degree students. The 2013 survey data asked survey takers to rate their level of interest in a career sector on a five-point scale (five being very interested); although different measures were used in 2013, the results show a similar pattern and order of career interests in the five different career sectors.

Taking into account the different job areas in the Industry sector, students were more likely to select Research & Development (56.5%) than other job areas when asked about their level of interest, followed by Manufacturing (13.8%). Considering the job areas in Academia, students were more likely to select that they were "very interested" in being a Professor at a Research Institution (44.8%), followed by their interest in being a Professor at a Primarily Undergraduate Institution (39.8%). It is important to note a distinction between the interests of male versus female respondents in academia, where females (36.4%) were far less likely than males (52.2%) to select that they were "very interested" working as a Professor at a Research Intensive Institution. They were more likely to select that they were interested in working as a Professor at a Primarily Undergraduate Institution, as well as working as a member of Academic Professional Staff. Considering job areas for Entrepreneurship, male respondents (52.7%) were much more likely than females (15.4%) to say they were interested starting their own company. This difference in gender responses echoes the overall results of the *2013 Graduate Student Survey*.

For an indication of how their interests may have changed since the start of graduate school, students were asked what their top career interests had been at the beginning in comparison to

Table 3.1.1. Current Top-Ranked Career Interest (Percentage of Responses Ranked Number One)

Category	All respondents (n=2,473)	Female respondents (n=1,027)	Male respondents (n=774)	Doctoral degree students (n=2,274)	Master's degree students (n=199)
Academia	38.0	34.0	40.8	38.0	37.2
Entrepreneurship	4.9	3.8	7.1	5.0	3.5
Government	11.6	14.1	8.8	11.6	12.1
Industry	41.2	41.8	40.4	41.1	41.7
Nonprofit	4.4	6.3	2.8	4.3	5.5

their current interests (Table 3.1.2). Responses to this question showed that graduate students' interest levels were initially highest for Academia (48.9%), followed by Industry (37.5%), implying that a swap in interest levels occurred during their graduate studies. Current interests in other career sectors (i.e., Government, Entrepreneurship, and Nonprofit) were generally reported as being higher than they were at the start of graduate studies. Considering gender differences, male respondents (52.7%) were more likely than females (43.9%) to say they were interested in working in academia at the start of their graduate studies. The detected trend in changing career interests as graduate students progress in their degree programs is consistent with findings from in-depth studies by Sauermann et al. These studies found that students are more likely to make informed career decisions if they know about available career options, work environments, and required skill sets.^{9,21} To explore the readiness of graduate students to make informed career decisions, the study asked them to rate their perceived quality of knowledge about career sectors such as academia, entrepreneurship, government, industry, and nonprofit. Results were grouped into work areas that correspond to for-profit, nonprofit, and academic organizations (Table 3.1.3). Graduate students perceived that, in comparison, they had the highest quality of knowledge about the academic work area, followed by for-profit and nonprofit organizations, respectively. This suggests that graduate students might benefit from learning more about work areas, specifically nonacademic ones, to enhance their informed career decision making. This finding is aligned with "Recommendation 4.2—Career Exploration for Master's Students" and "Recommendation 5.2—Career Exploration and Preparation for Ph.D. Students" from the National Academies Press report on *Graduate STEM Education for the 21st Century* (2018).¹

Table 3.1.2. Top-Ranked Career Interest at Start of Graduate School (Percentage of Responses Ranked Number One)

Category	All respondents (n=2,374)	Female respondents (n=1,014)	Male respondents (n=761)	Doctoral degree students (n=2,191)	Master's degree students (n=183)
Academia	48.9	43.9	52.7	49.8	38.3
Entrepreneurship	2.9	2.3	4.3	2.9	3.3
Government	9.0	12.6	5.0	8.6	14.2
Industry	37.5	38.8	36.9	37.1	42.6
Nonprofit	1.6	2.5	1.1	1.6	1.6

Table 3.1.3. Perceived Quality of Knowledge About Three Work Areas (n=2,516). The Perceived Quality of Knowledge Was Measured on a 5-Point Scale, Where 5 = Excellent, and 1=Poor.

Work area	Mean (SD)
Academia	3.70 (.95)
For-Profit ^A	2.44 (1.16)
Nonprofit	1.79 (.97)

^AFor-Profit includes Entrepreneurship, Government, and Industry

Gibbs et al. described the role of personal values in shaping the career interests of biomedical science doctoral degree graduates.⁴¹ The 2019 ACS Graduate Student Survey also explored internal and external factors that influence career choice (where "internal" refers to core values that motivate individuals, and "external" refers to contextual or environmental circumstances that factor in). As seen in Table 3.1.4A (summarizing internal

factors), a desire for "Balance: Equilibrium between personal and business activities," was cited as "very or extremely important" by 86.8% of the respondents. A job that offers "Security: Stability and predictability" also ranked highly for all students (84.2%), and was a more significant factor

for female respondents (86.6%) than for male ones (81.7%) (data for female vs. male responses not shown). Female respondents (61.1%) were more likely than male ones (52.1%) to place importance on finding a job in a specific geographical location.

These findings also mirrored the 2013 Graduate Student Survey results concerning relative prioritization of internal factors. Looking at Asian and respondents from underrepresented groups in comparison to White respondents, the importance of Salary, Altruism, and Leadership were rated more highly by Asian and underrepresented students in comparison to White students.

Considering values as rated by different groups (Table 3.1.4B), the data showed there was a significant difference between how Asian and respondents from underrepresented groups, in comparison to White respondents, tended to rate the importance of different values. Asian respondents tended to rate the importance of Salary (82.4%), Advancement (80.2%), Autonomy (76.7%), and Leadership (64.5%) consistently more than 10% higher than White respondents, as well as 9% or more higher when considering the composite response of all survey respondents. By and large, Asian respondents tended to rate the importance of values higher in comparison to White respondents. The one exception to this case was the importance of Balance, which was rated 5% lower in comparison to White respondents. Although the small number of survey respondents who identified as Black or African American does not allow the authors to assert a statistically significant comparison with the composite group (Black or African Americans represented 2.5% of the survey respondents), the data suggests interesting differences between the values ratings of Asian and African American respondents in comparison to other groups. In particular, the importance of Salary (86.2%), Altruism (84.5%), Autonomy (76.7%), and Leadership (64.6%) were rated much higher in comparison to both the composite of survey respondents and White survey respondents (data not shown). Although further studies with higher values of n for the different subgroups would be necessary to reach a conclusive theory, these initial observations of the data suggest a difference of level-of-importance of values based on ethnicity that is impactful to the career

Table 3.1.4A. Internal Values That Are Important to Students' Choice of Careers

Category	Percentage marking "very or extremely important"
Balance: Equilibrium between personal and business activities (n=2,332)	86.8
Security: Stability and predictability (n=2,334)	84.2
Challenge: Drive to overcome obstacles and solve problems (n=2,329)	76.1
Salary: Finding a well-paying job (n=2,335)	73.0
Autonomy: Freedom and ability to be self-directed (n=2,337)	66.8
Advancement: Opportunity for promotion and recognition from others (n=2,337)	65.9
Interests: Changing intellectual interests (n=2,330)	64.5
Discovery: Developing understanding for its own sake (n=2,332)	61.7
Altruism and Volunteerism: Opportunity to contribute to the welfare of others (n=2,335)	60.6
Location: Desire to have a job in a certain geographical location (n=2,334)	58.0
Leadership: Supervisory, management, and executive-level positions (n=2,334)	53.0
Perfectionism: Doing things exactly right, no matter how long it takes (n=2,333)	34.8
Public Contact: Day-to-day contact with customers (n=2,334)	17.9

Note: "Not applicable" responses and NA's were excluded. Important includes "very" and "extremely" important.

Table 3.1.4B. Internal Values That Are Important to Students' Choice of Careers

Category	Percentage marking “very or extremely important”			
	Total (N=1,811)	Black or African American (n=58)	Asian (n=370)	White (n=1,272)
Balance: Equilibrium between personal and business activities (n=2,332)	86.8*	91.4	83.0	88.4
Security: Stability and predictability (n=2,334)	84.2	93.1	85.9	83.5
Challenge: Drive to overcome obstacles and solve problems (n=2,329)	76.1*	87.9	81.0	73.7
Salary: Finding a well-paying job (n=2,335)	73.0*	86.2	82.4	68.4
Autonomy: Freedom and ability to be self-directed (n=2,337)	66.8*	74.1	76.7	62.6
Advancement: Opportunity for promotion and recognition from others (n=2,337)	65.9*	74.1	80.2	59.4
Interests: Changing intellectual interests (n=2,330)	64.5*	70.7	74.1	60.8
Discovery: Developing understanding for its own sake (n=2,332)	61.7*	75.4	75.8	54.6
Altruism and Volunteerism: Opportunity to contribute to the welfare of others (n=2,335)	60.6*	84.5	62.2	57.9
Location: Desire to have a job in a certain geographical location (n=2,334)	58.0	55.2	58.3	57.5
Leadership: Supervisory, management, and executive-level positions (n=2,334)	53.0*	74.1	64.5	47.4
Perfectionism: Doing things exactly right, no matter how long it takes (n=2,333)	34.8*	50.0	47.8	28.2
Public Contact: Day-to-day contact with customers (n=2,334)	17.9*	26.3	29.2	13.1

*Indicates that there is at least one racial background (Asian, Black or African American, or White) whose responses are significantly different from the others.

Notes: “Not applicable” responses and NA’s were excluded. Important includes “very” and “extremely” important

decision-making of chemical scientists. This observation is consistent with literature that posits a difference in career motivation of STEM students who are from underrepresented groups and people of color in comparison to those who identify as the majority or as White.^{22,23,24} As shown in Table 3.1.5. (summarizing external factors), “Self-assessment/self-awareness” was cited as “very or extremely influential” with respect to choice of career by 86.6% of graduate students. It should be noted that in social psychology, the definition of self-assessment lends itself to having both an internal (how one assesses one’s self) and an external (how others assess one’s self) component. In this survey, “Self-awareness” was listed as an external factor as opposed to an internal factor, although the authors demur, saying that it could have arguably belonged to either

Table 3.1.5. External Factors Influential to Students' Choice of Careers

Category	Percentage marking "very or extremely influential"
Self-assessment/self-awareness (n=2,289)	86.6
Job prospects in your field (n=2,290)	77.8
Knowledge of different career areas (n=2,280)	75.2
Encouragement by a mentor to pursue a specific career goal (n=2,290)	53.8
Discussion with and encouragement by peer-mentors (other students or postdocs) (n=2,289)	52.0
Spouse/partner (n=2,276)	50.7
Encouragement by a research advisor to pursue a specific career goal (n=2,291)	49.8

category. "Job prospects in your field" were cited as "very or extremely influential" as a factor for determining career choice for 77.8% of graduate students. This was followed closely by "Knowledge of different career areas" (75.2%) as an influential factor to career choice. In considering encouragement and support that might come from various relationships (e.g., mentors, research advisors, spouse/partner, or peer-mentors), results indicated that students cited "Encouragement by a mentor" to pursue a specific career goal as the most influential factor (53.8 %), followed by closely by "Discussion with and encouragement by peer-mentors" (52.0%), "Spouse/partner" (50.7%), and "Encouragement by a research advisor" (49.8%). In considering gender differences, female respondents were more likely than males to cite "Knowledge of different career areas" (79.7% vs. 69.4%) and "Self-awareness" (88.4% vs. 84.1%) as influential factors in their choice of career.

The 2013 Survey did not include "Self-awareness" as an option and additionally had only one item corresponding to encouragement by an advisor or mentor to pursue a specific career goal. Taking these differences into account, the "Spouse/partner" as an influential factor was cited at a lower rate in this 2019 Survey (50.7%) than in the 2013 Survey (60.1%). Other factors were in close proximity to the 2013 Survey results.

Considering career goals and potential barriers to career planning and development, how useful do graduate students find available career resources? Data in Table 3.1.6. show that "Search engine[s] (e.g., Google, Bing, etc.)" were deemed "Extremely/very useful" by 55.9% of the respondents. In-person career events such as "Professional conferences/meetings" and "Networking events outside of professional conferences/meetings" were also deemed "extremely/very useful" (48.6% and 41.0% respectively). "Social media (incl. Facebook, Instagram, LinkedIn, Twitter)" was cited by 31.9% as "extremely/very useful."

Sauermann et al. suggested that providing detailed career path information to students prior to enrollment in a graduate program may allow them to more accurately evaluate the costs and benefits of pursuing a Ph.D.⁹

The 2019 ACS Graduate Student Survey asks participants, "In your opinion, when is the best time to learn about career areas and opportunities for graduate degree holders in the chemical sciences?" Data in Table 3.1.7. show that nearly 49% of respondents felt that information about career areas and opportunities for graduate degree holders in the chemical sciences should be provided prior to enrollment in the graduate program. About 21% and 20% felt that this informa-

Table 3.1.6. Usefulness of Career Resources

Resource type	Percentage marking “extremely/very useful”
Search engine (e.g., Google, Bing, etc.)	55.9
Professional conferences/meetings	48.6
Networking events outside of professional conferences/meetings	41.0
Social media (incl. Facebook, Instagram, LinkedIn, Twitter)	31.9
Career resources from a scientific or professional society/association	29.5
Career development/counseling center at your institution	20.8
Graduate Studies Office at your institution	16.4
Blogs	13.6
Webinars	12.9
Podcasts	8.9

Table 3.1.7. Best Time To learn About Career Areas and Opportunities for Graduate Degree Holders In the Chemical Sciences (n=2,580)

Time frame	Percentage of Total number of records
Before starting graduate school	48.8
During years 1-2 of graduate school	21.2
During years 3-4 of graduate school	19.8
During the last two years in graduate school	10.3

tion should be provided within the first two years or during the third and fourth years of graduate school, respectively. Only 10% felt that this career-related information would be helpful during their last two years in graduate school.

This data supports Sauermann’s suggestion to provide detailed career path information to students prior to enrollment in a graduate program.

3.2. Graduate Education Competencies

The National Academies of Sciences, Engineering, and Medicine appointed the Committee on Revitalizing Graduate STEM Education for the 21st Century to examine the state of U.S. graduate STEM education and “how the system might best respond to ongoing developments in the conduct of research on evidence-based teaching practices and in the needs and interests of its students and the broader society it seeks to serve.” The committee published its findings and recommendations in the National Academies Press report on *Graduate STEM Education for the 21st Century* (2018).¹ A critical element of the report was the articulation of the core competencies that all students who have been through U.S. graduate STEM education should acquire, at both the master’s and the doctoral degree levels.

The 2019 ACS Graduate Student Survey examined how masters’ and doctoral degree students rated themselves in the competency areas described in the National Academies Press report on *Graduate STEM Education for the 21st Century* (2018).¹ For masters’ degree students, core competencies included “Disciplinary and interdisciplinary knowledge,” “Professional compe-

Table 3.2.1. Master's Degree Students' Self-Reported Core Competency Ratings

Core competency	Mean* (SD)	
Disciplinary and interdisciplinary knowledge: Developed core disciplinary knowledge and the ability to work between disciplines. (n=163)	4.01	(0.89)
Professional competencies: Developed abilities defined by a given profession (e.g., chemical sciences). (n=163)	4.02	(0.87)
Foundational and transferable skills: Developed skills that transcend disciplines and are applicable in any context, such as communications, leadership, and working in teams. (n=164)	4.13	(0.93)
Research: Developed the ability to apply the scientific method, understand the application of statistical analysis, gain experience in conducting research and other field studies, learn about and understand the importance of research responsibility and integrity, and engage in work-based learning and research in a systematic manner. (n=164)	4.06	(0.95)

*Each question was measured on a 5-point scale, where 5 = strongly agree and 1 = strongly disagree.

tencies,” “Foundational and transferrable skills,” and “Research.” Data in Table 3.2.1 show that masters’ degree students’ rating for all core competencies was overall above a mean of 4. The highest rating was associated with foundational and transferrable skills such as communication, leadership, and teamwork skills.

The Committee on Revitalizing Graduate STEM Education for the 21st Century published ten core competencies for doctoral degree students that fall under the two categories, “Develop Scientific and Technological Literacy and Conduct Original Research” and “Develop Leadership, Communication, and Professional Competencies.” Data in Table 3.2.2 show that doctoral degree student respondents feel that their graduate education to date helped them to develop robust competencies under both main categories. The highest and the lowest mean ratings for the “Develop Scientific and Technological Literacy and Conduct Original Research” competency cluster were associated with ethical conduct of research (4.08) and “sufficient trans-disciplinary literacy to suggest multiple conceptual and methodological approaches to a complex problem” (3.80).

The highest and the lowest mean ratings for the “Develop Leadership, Communication, and Professional Competencies” cluster were associated with collaborative/team work (4.21) and “professional competencies, such as interpersonal communication, budgeting, project management, or pedagogical skills that are needed to plan and implement research projects” (3.66).

Overall, master's degree students seem to feel more proficient in their core competencies than doctoral degree students. It must be emphasized that this survey captured self-reported data. Other studies might want to compare self-reported data with data from corresponding advisors or mentors and from peers.

3.3 Contextual Factors (Advisors and Mentors, Resources, Support & Satisfaction)

Graduate students receive their education and training in unique environments. The success and satisfaction of each graduate education experience is shaped by many factors. Factors span everything from psychological support from family, friends, faculty advisors, mentors, departments, and institutions to the availability of benefits, regulated leave times, internship and international opportunities, and appropriate financial support. In this section, we will describe the

Table 3.2.2. Doctoral Students' Self-Reported Core Competency Ratings (n=1,924)

Competency	Mean* (SD)
Develop Scientific and Technological Literacy and Conduct Original Research	
Developed deep specialized expertise in chemistry or chemical engineering. (n=1,920)	3.94 (0.88)
Acquired sufficient trans-disciplinary literacy to suggest multiple conceptual and methodological approaches to a complex problem. (n=1,920)	3.80 (0.92)
Able to identify an important problem and articulate an original research question. (n=1,918)	3.87 (0.88)
Able to design a research strategy, including relevant quantitative, analytical, or theoretical approaches, to explore components of the problem and begin to address the question. (n=1,920)	3.99 (0.84)
Able to evaluate outcomes of each experiment or study component and select which outcomes to pursue and how to do so through an iterative process. (n=1,919)	4.04 (0.80)
Adopted rigorous standards of investigation and acquired mastery of the quantitative, analytical, technical, and technological skills required to conduct successful research in the field of study. (n=1,915)	3.94 (0.86)
Learned and are able to apply professional norms and practices of the scientific or engineering enterprise, the ethical responsibilities of scientists and engineers within the profession and in relationship to the rest of society, as well as ethical standards which will lead to principled character and conduct. (n=1,918)	4.08 (0.84)
Develop Leadership, Communication, and Professional Competencies	
Developed the ability to work in collaborative and team settings involving colleagues with expertise in other disciplines and from diverse cultural and disciplinary backgrounds. (n=1,916)	4.21 (0.84)
Acquired the capacity to communicate, both orally and in written form, the significance and impact of a study or a body of work to all STEM professionals, other sectors that may utilize the results, and the public at large. (n=1,920)	4.08 (0.83)
Developed professional competencies, such as interpersonal communication, budgeting, project management, or pedagogical skills that are needed to plan and implement research projects. (n=1,919)	3.66 (1.01)

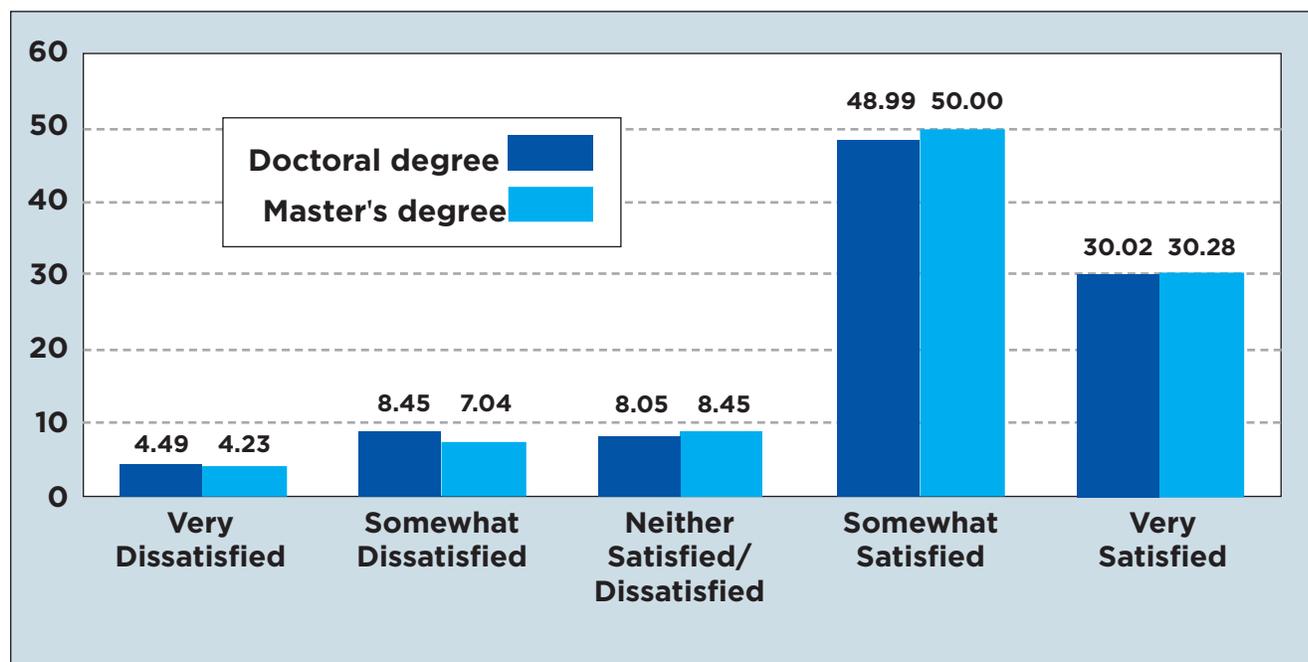
*Each question was measured on a 5-point scale, where 5 = strongly agree and 1 = strongly disagree.

2019 ACS Graduate Student Survey results associated with these contextual factors.

3.3.1 Overall Satisfaction, Degree Completion, and Change

Several questions in the present study probed graduate students' satisfaction with graduate school. In response to the question, "How satisfied are you with your overall graduate school experience at your current institution?" 79.0% of doctoral degree students and 80.3% of master's degree students indicated that they were "very" or "somewhat" satisfied (Figure 3.3.1.1). These levels of satisfaction are comparable to those described in the *2013 ACS Graduate Student Survey Report* and studies probing the satisfaction of postdoctoral researchers.^{4,25}

Figure 3.3.1.1. Students' Satisfaction With Overall Graduate Experience at Current institution by Degree Type (Percentages)



The extent to which graduate students intend to complete a degree and to stay in the chemical sciences can also be used as indicators of satisfaction. Table 3.3.1.2 indicates that 68% of doctoral degree and 86% of master's degree students intend to “definitely” complete their degree. (Note: The calculated percentage of doctoral degree students and master degree students reporting they “definitely will” complete their degree in the 2013 Survey is 76.6% and 88.9%, respectively).

In addition, data associated with the likelihood of degree completion were analyzed for gender, race/ethnicity, and citizenship status differences. There was no significant difference for gender. Statistical significance was found when the data were analyzed for race/ethnicity and for citizenship. Graduate students who identified as White were less likely than Asian and graduate students from underrepresented groups to respond that they “definitely will” complete their graduate degree; a statistically significant result (77.8%, 77.8%, 78.8%, respectively). Among visa holders, 81.3% indicated that they “definitely will” complete their degree, while only 67.2% of U.S. citizens and permanent residents checked the same option.

When asked about the likelihood of staying in the chemical sciences after degree completion, about 80% of doctoral and master's degree students indicated that they were “extremely” or “very” likely to stay in the chemical sciences. A notable increase of 10% for masters' degree students can be detected (Table 3.3.1.3) when comparing the 2013 to the 2019 survey results. The chance of doctoral degree students remaining in the chemical sciences after graduation remained the same.

When asked what survey respondents would change if they were able to start over, roughly 10% would change their current field of study, ~14% would change their current institution, and ~16% would change their primary research advisor (Table 3.3.1.4). No significant difference is detected between the presented results for 2019 and those from the 2013 ACS Graduate Student Survey.

3.3.2 Research Groups and Advisors

In science and engineering, research is often laboratory intensive, and the historical approach to

Table 3.3.1.2. Fraction of Students Who “Definitely Will” Complete Their Graduate Degree (Completion by Degree Type and Survey Year)

2019		2013	
Doctoral degree (n=2,400)	67.7%	Doctoral degree (n=2,698)	76.7%
Master’s degree (n=217)	86.2%	Master’s degree (n=232)	88.9%

Table 3.3.1.3. Likelihood Student Will Remain In the Chemical Sciences After Graduation

2019		2013	
Doctoral degree (n=2,032)	75.84%	Doctoral degree (n=2,698)	76.1%
Master’s degree (n=174)	83.33%	Master’s degree (n=232)	72.3%

Table 3.3.1.4. Factors Respondents Would Change If Given the Opportunity To Start “Graduate Studies Over” (N=1,878)

Factors	Percent Marking*	
	“Yes, I would change this”	“No, I would not change this”
Current field of study	9.8	60.7
Current institution	14.3	47.4
Primary research advisor	15.9	56.3

Note: “maybe” and “n/a” options omitted
 * Using 2013 methodology

higher education continues to be based on an apprenticeship model.^{1,26} In this model, the student (“apprentice”) works under the supervision of a primary research advisor, who plays a key role in providing the deep knowledge required for graduate students to develop into independent researchers.

It has been reported by O’Meara and collaborators, and highlighted by the National Academies Press report on *Graduate STEM Education for the 21st Century* (2018),¹ that “a student’s relationship with his or her primary advisor is the factor most directly correlated with retention, timely completion, sense of inclusion, career aspirations, and overall satisfaction with her or his graduate experience.”²⁷ Additional studies have reported that “the best faculty advisors improved academic success, research productivity, career commitment, and self-efficacy.”^{28,29}

In light of this literature, a series of survey questions probed the relationship between graduate students and their advisors as well as other interpersonal relationships that influence the research-training environment and a student’s overall support during graduate school.

Out of the total of student survey respondents, 94.6% reported being “currently in a research group” (N=2,086; Table E.1., on page 51 in the appendices). The remaining 5.4% could reflect the percentage of survey respondents who were still in early stages of their graduate experience and had not officially joined a research group at the time of this survey.

To understand the main factors considered by students in the process of selecting a research group, students were asked to respond to the question, “Why did you decide to join your current research group?” A word frequency analysis of the students’ answers indicated “Research” as

the main factor considered by students while selecting a research group, followed by “Interest,” “Group,” and “Advisor” (Figure 3.3.2.1). Additionally, a correlation analysis indicated that “Research” and “Group” were not significantly correlated and were only found to be used together with a 0.35 frequency, which might indicate that when referring to “Research,” the respondents were frequently referring to their research interest (0.44 frequency) rather than to the “Research Group” (Table E.2. on page 51 in the appendices). Even though “Group” was the third highest represented word, there were no references to the size of the research group in the responses. This might suggest that group size is either not a relevant factor in the students’ decision-making process or that it was simply not reported. The fourth most represented consideration in joining a research group was “Advisor.”

Figure 3.3.2.1. Students’ Considerations in the Decision To Join a Research Group



To get more insights into the specifics of the student–advisor relationship and overall support, students were asked to respond to the question, “To what extent does each of the following behaviors describe your primary research advisor?” As shown in Table 3.3.2.2, there was no significant difference in the advisor behaviors reported by male and female students. However, when these responses are analyzed in conjunction with the gender of the advisor (Table 3.3.2.2, C1 and C2), this study found that female advisors were more likely than male advisors to encourage students to present at conferences, as well as to engage them in writing grant proposals. Additionally, a significantly higher number of students with female advisors indicated that their advisor “Takes time to learn about my background, interests, and/or personal relationships” to a “considerable” or “great extent” in comparison to the students with male advisors.

Among the respondents, 65.5% of students reported that their advisor created an environment where group members were treated fairly to a “considerable” or “very great” extent. Additionally, 60% of the students indicated that their advisor “Is receptive to my emotional health” to a “considerable” or “very great” extent. There was no difference in the responses from female and male students.

As shown in Table 3.3.2.2 (D1 and D2), doctoral degree students were more likely than master’s degree students to report that, to a “considerable” or “very great” extent, their advisors asked them “...to write the first drafts of scientific manuscripts.” However, master’s degree students were more likely than doctoral degree students to indicate that their advisors to a “considerable” or “very great” extent provided regular feedback on progress toward degree completion, helped them in developing professional relationships, and provided information on nonacademic career paths. Additionally, master’s degree students were more likely than doctoral degree students to report to a “considerable” or “very great” extent that their advisors take time to learn about their background, interests, and/or personal relationships as well as create an environment where all group members are treated fairly.

Table 3.3.2.2 Ratings of Behaviors of Primary Advisor (For Those Students with One Advisor, by Gender, Gender of the Advisor, Degree Type, Race)

Behaviors	Percentage Indicating That Each Behavior Is Descriptive of Advisor to a “Considerable” or “Very Great” Extent								
	A	B1	B2	C1	C2	D1	D2	E1	E
	All students	Female respondents	Male respondents	Female advisor	Male advisor	Doctoral degree students	Master’s degree students	Female (Asian or from under-represented groups)	General population
Asks me to write the first drafts of scientific manuscripts	73.1	74.3	73.6	75.6	72.3	74.5*	51.9	74.2	73.7
Engages me in writing grant proposals	34.4	35.7	32.6	38.5	32.8*	34.8	28.6	32.5	34.7
Encourages me to take responsibility for designing the projects that I work on	76.9	76.3	79.4	76.7	77.3	77.1	74.3	78.0	78.0
Encourages me to gain independence over the course of my graduate studies	85.7	86.7	85.7	85.7	86.3	85.6	87.7	82.6	87.8
Encourages me to present our research at scientific conferences	68.4	69.9	66.9	76.7	65.8*	68.4	68.9	70.7	68.4
Gives regular feedback on my research	69.5	69.4	69.4	72.8	68.6	69.2	74.5	73.4	69.0
Gives regular feedback on my progress towards degree completion	46.7	47.8	44.5	49.0	46.1	45.7	62.9*	54.5*	44.6
Gives the appropriate level of credit to me for my research contributions	79.6	80.9	78.9	82.4	79.0	79.7	78.3	76.4	81.3
Helps me to develop professional relationships	49.8	51.1	48.5	51.9	49.3	48.9	64.2*	52.4	49.4
Advocates for me	69.8	71.9	67.9	73.5	68.8	69.3	77.4	69.6	70.4
Provides information about academic career paths	43.8	44.2	42.5	44.4	43.8	43.4	50.5	48.7	42.5
Provides information about non-academic career paths	29.0	29.6	28.1	29.8	28.9	28.2	41.5*	35.1	28.2
Supports my career path of choice	67.6	68.1	68.1	68.0	68.0	67.4	71.7	67.5	68.5
Models good professional relationships	69.4	70.7	68.2	73.2	68.5	69.1	73.3	68.1	69.8
Encourages me to take on challenging opportunities	76.5	75.1	79.0	77.4	76.5	76.4	77.4	71.2	78.2*
Encourages me to attain my goals	75.5	75.4	76.4	78.6	74.7	75.1	82.1	71.2	76.6
Takes time to learn about my background, interests, and/or personal relationships	49.5	49.2	50.3	55.1	47.8*	48.4	66.0*	53.9	49.2
Creates an environment where all group members are treated fairly	65.5	64.4	67.5	67.6	65.1	64.6	78.3*	57.6	66.9*
Is receptive to my emotional health	60.0	60.7	60.3	63.8	59.1	59.4	68.9	59.2	60.8

*p<0.05

Column A: N=1,735

Columns B1, B2: Female respondents: n=856, Male respondents: n=674

Columns C1, C2: z-tests were performed to determine whether all students, as well as male and female students with a male or female advisor, responded differently;

F: n=443, M: n=1,276; FF: n=243, FM: n=609, MF: n=151, MM: n=516; N=1,719

Columns D1, D2: Doctoral degree students: n=1,629, Master’s degree students: n=106

Columns E1, E2: Asian and underrepresented female respondents (all URM women and Asian women (U.S. native, U.S. naturalized, U.S. permanent residents, or J-1, F-1, and H1-B visa-holders): n=191; General population (all male respondents including J-1, F-1, H1-B visa-holders) and white female respondents (U.S. native, U.S. naturalized, U.S. permanent residents, or J-1, F-1, and H1-B visa-holders): n=1,232; “Other visa” and “Other race” responses were excluded from this analysis.

Additionally, “Non-binary/third gender”, “Prefer to self-describe”, and “Prefer not to say” responses were excluded.

Consistent with the 2013 ACS Graduate Student Survey⁴ data, fewer than 50% of graduate students indicated that their advisor “Gives regular feedback on my progress towards degree completion” to a “considerable” or “very great” extent. Consistently, the data in this study indicate that the percentage of female students who reported receiving “regular feedback towards degree completion” from their advisor to a “considerable” or “very great” extent was not dependent on the advisor gender (46.9% for female advisors; 48.2% for male advisors). However, for male students, the percentage of those who reported receiving “regular feedback towards degree completion” from their advisor to a “considerable” or “very great” extent was significantly different for students with a female and male advisors (54.3% vs. 41.9%; $p=0.009$).

Equity in graduate education can be defined in a variety of ways. The NSF INCLUDES Alliance: Inclusive Graduate Education Network³⁰ works toward reconfiguring structures and cultures in the system of graduate education to empower marginalized groups and close disparities.

The 2019 ACS Graduate Student Survey report compares responses from female respondents who are Asian or from underrepresented groups to those from all male and white female (general population) respondents in Table 3.3.2.2. (E1 and E2). Three significant differences surfaced when focusing on the behaviors of faculty advisors. About 10% more female respondents who are Asian or from underrepresented groups indicated that they feel their advisor provides regular feedback on the progress towards degree completion than the general population. Among female respondents who are Asian or from underrepresented groups, 72% indicated that their advisor encourages them to take on challenging opportunities, in comparison to 79% for the general population. Only 58% of female respondents who are Asian or from underrepresented groups feel that their advisor builds an environment where “all group members are treated fairly,” in comparison to 66% for the general population.

Students were asked to indicate their level of agreement with a series of statements regarding their relationship with their primary research advisor and their perceptions of their primary research advisor’s viewpoints (Table 3.3.2.3.). In response to the statement, “I get along well with my primary advisor,” 84.2% of respondents stated that they “strongly” or “somewhat” agreed. Additionally, the majority of students (72.1%) indicated being satisfied with the amount and quality of time spent with their research advisor. More than three-fourths of respondents also agreed “strongly” or “somewhat” that their advisor sees them as a productive member of the research group. However, a lesser percentage of students (69.8%) agreed “strongly” or “somewhat” that their advisor “is satisfied with my research productivity.” In contrast to the data reported by the 2013 ACS Graduate Student Survey, where there were significant differences between female and male students’ responses in regard to some aspects of the relationship with their advisor, this study found that the students’ perceptions of their relationship with the advisor did not differ significantly for female and male students. More than one-fourth of the students “strongly” or “somewhat” agreed with the statement, “My primary research advisor is out of touch with the career issues that graduate students face.” Although this response was not significantly different for female and male students, students with a male advisor were significantly more likely to “strongly” or “somewhat” agree with that statement than students with a female advisor (Table 3.3.2.3., C1). For all other statements reflecting aspects of the advisor–student relationship, students’ perceptions of these behaviors did not differ significantly between students with female or male advisors.

Graduate students were also asked for their perceptions of the amount of support and advice they currently received and the ideal level of support and advice they desire for their professional development and career. As shown in Table 3.3.2.4. on page 27, family and friends are the

primary sources of support for both doctoral and master’s degree students. Only 39% of doctoral degree students and 43% of master’s degree students reported receiving “a lot” of support from their primary research advisor. However, 72.3% of doctoral degree students and 65.2% of master’s degree students reported ideally desiring “a lot” of support from their primary research advisor.

Interestingly, master’s degree students, more than doctoral degree students, reported receiving “a lot” of support from an alumnus/a and other faculty besides their primary research advisor at their current institution. Doctoral degree students were more likely than master’s degree students to report getting “none” or “moderate” support from their primary research advisor, other faculty, postdocs, administrators and staff members, or an alumnus/a at their current institutions, but they indicated desiring a higher level of support from these individuals.

Data in Table 3.3.2.5. on page 28 indicate that female respondents were more likely than male ones to indicate that they received “a lot” of support from family and friends. Additionally, male respondents were more likely to report getting “none” or “moderate” support from family and friends. However, male respondents did not report desiring additional support from these groups, while a higher percentage of female ones did. Additionally, female respondents more than male ones reported desiring more support from other groups, such as their fellow graduate students.

3.3.3 Funding and Living

Table 3.3.2.3. Ratings of Relationship With Primary Advisor (For Those Students with One Advisor, by Gender)

Percentage indicating they “strongly” or “somewhat” agree with each statement					
Statement	A All students	B1 Female respondents	B2 Male respondents	C1 Female advisor	C2 Male advisor
I am satisfied with the amount and quality of time spent with my primary advisor.	72.1	73.1	72.0	72.4	72.4
My primary advisor is satisfied with my research productivity.	69.8	72.1	67.6	69.8	70.2
I get along well with my primary advisor.	84.2	85.1	84.4	84.8	84.2
My primary research advisor is out of touch with the career issues that graduate students face.	26.9	24.1	26.7	20.3	28.8*
My primary research advisor sees me as a productive member of the research group.	78.3	79.1	78.3	79.3	78.3

* p<0.05

Column A: N=1,718, Columns B1, B2: N=1,718, Female respondents: n=856; Male respondents: n=673
 Columns C1, C2: z-tests were performed to determine whether all students, as well as male and female respondents with a male or female advisor, responded differently; N=1,703; F: n=440, M: n=1,263; FF: n=243, FM: n=609, MF: n=151, MM: n=515

Table 3.3.2.4. Current and Ideal Amount of Support for Graduate Students' Professional Development and Career, by Degree Type (N=1,944^a and 1,859^b)

Source of Support	Percentage Indicating They Currently Have ^a :				Percentage Indicating They Ideally Desire ^b :			
	Doctoral degree	Master's degree	Doctoral degree	Master's degree	Doctoral degree	Master's degree	Doctoral degree	Master's degree
	"A lot of support"		"None" or "moderate" support		"A lot of support"		"None" or "moderate" support	
Administrators and staff members at your current institution	17.6	21.2	80.6*	73.5	26.1	33.8	72.2*	61.9
Alumnus/a from institution	5.3	11.3*	84.7*	70.2	14.9	13.0	77.0*	68.1
Family	44.8	47.7	53.0	50.3	46.3	47.8	51.0	50.7
Friends	41.1*	31.8	56.7	65.6*	44.8	43.2	52.6	55.4
Postdocs at your current institution	15.5	15.3	69.6*	48.7	27.1	22.1	59.8*	43.4
Primary research advisor	39.0	43.0	59.2*	41.1	72.3	65.2	26.5	23.2
Professional colleagues outside of your current institution	11.8	15.2	77.4	70.9	20.8	28.5*	69.6*	59.9
Other faculty (besides your primary research advisor) at your current institution	9.9	25.2*	86.9*	66.9	21.2	34.5*	75.4*	58.3
Other graduate students at your current institution	32.0	30.5	67.1	64.2	39.0	38.1	59.8	56.8
Other	9.5	7.3	14.9	22.0	11.8	14.3	13.7	17.1

*p<0.05

^aDoctoral degree students: n=1,793; master's degree students: n=151

^bDoctoral degree students: n=1,720; master's degree students: n=139

Note: The "Other" option had 356 responses (M.S.: 41, Ph.D.: 315) and 348 responses (M.S.: 35, Ph.D.: 313) respectively

This study also addresses the differences in funding mechanisms currently used to support graduate students in the chemical sciences. Additionally, it provides information about the graduate students' perceptions of funding adequacy to meet their living standards. As shown in Table 3.3.3.1. on page 29, the majority of survey respondents are funded by "Teaching assistantships" (31.6 %) and "Research assistantships" (26.5%), while a smaller percentage (16.2 %) reported being funded by "Multiple sources." The number of graduate student respondents who are currently being supported exclusively by "Fellowship/Scholarships/Traineeships" is only 15.7%.

Table 3.3.2.5. Current and Ideal Amount of Support for Graduate Students' Professional Development and Career, by Gender (N=1,791^a and 1,725^b)

Source of Support	Percentage Indicating They Currently Have ^a :				Percentage Indicating They Ideally Desire ^b :			
	Female	Male	Female	Male	Female	Male	Female	Male
	Respondents		Respondents		Respondents		Respondents	
	"A lot of support"		"None" or "moderate" support		"A lot of support"		"None" or "moderate" support	
Administrators and staff members at your current institution	17.8	18.5	80.1	79.7	26.4	26.4	71.8	72.0
Alumnus/a from institution	5.4	5.9	83.3	85.4	13.3	16.2	77.8	75.7
Family	49.1*	39.2	48.4	59.1*	51.9*	38.9	45.3	58.9*
Friends	45.7*	33.6	51.6	64.9*	51.6*	36.6	45.4	61.7*
Postdocs at your current institution	15.4	15.3	66.8	70.2	26.8	25.8	57.2	61.5
Primary research advisor	39.4	39.9	57.4	58.0	72.7	71.8	24.8	27.3
Professional colleagues outside of your current institution	11.4	12.7	76.6	77.5	21.5	20.2	68.5	70.0
Other faculty (besides your primary research advisor) at your current institution	10.8	11.5	85.3	85.8	20.8	23.4	75.6	73.0
Other graduate students at your current institution	33.8	29.8	65.1	69.0	41.3*	35.6	57.1	62.8*
Other	8.6	10.3	12.3	17.3	12.3	11.9	10.5	17.0

*p<0.05

^aFemale: n=1,023; Male: n=768

^bFemale: n=989; Male: n=736

Note: The "Other" option had 318 responses (F:162, M:156) and 321 responses (F:162, M:159) respectively

When graduate students were asked about their views on the adequacy of funding, 62.3% (n=848) of survey respondents agreed that their funding was adequate, while 27.3% (n=372) disagreed that their funding was adequate. It is important to highlight the fact that the 2013 ACS Graduate Student Survey results showed a higher percentage of students agreeing with the adequacy of their funding (69.1%, n=1,699) and a lower percentage disagreeing with the adequacy of funding (21.1%, n=519).

A comparison of the perceptions regarding funding adequacy among the different funding sources indicated that a higher percentage of students agreed with the adequacy of funding when

Table 3.3.3.1. Funding Mechanisms Currently Used To Support Graduate Students In the Chemical Sciences

Types of Funding	Types of funding among all respondents (N=1,220*)	Proportional Distribution of Funding Sources for Respondents Who:	
		Agree that their funding is adequate (n=848, 62.3%)	Disagree that their funding is adequate (n=372, 27.3%)
Teaching assistantship(s)	31.6	33.7	26.6
Research assistantship(s)	26.5	27.4	24.5
Fellowship/scholarships/traineeships	15.7	17.0	12.9
Loans and other support [†]	8.4	4.7	16.7
Do not wish to respond	1.6	1.5	1.9
Multiple sources	16.2	15.7	17.5

Notes:

Percentages of different funding sources for each group may not sum to 100 due to rounding.

Respondents' main (i.e., greatest) source of funding is reported.

"Multiple sources" represents the respondents whose main source of funding was from two or more sources.

* Omits respondents who answered "neither agree/disagree" that their funding is adequate to meet the cost of living where they live (n=70).

† Other support includes: Family support, Income from a spouse or partner, Industry, Personal savings, Other: U.S. sources, Other: Non-U.S. sources, and Other paid employment

they were supported by "Teaching assistantship(s)" (33.7%), than "Research assistantship(s)" (27.4%), and "Fellowship/scholarships/traineeships" (17.0%). However, the percentage of students who disagreed with the adequacy of funding followed similar trends. More students in Teaching assistantship(s) (26.6%), than Research assistantship(s) (24.5%) and Fellowship/scholarships/traineeships (12.9%) disagree that their funding was adequate.

A comparison of the perceptions regarding funding adequacy between female and male graduate students was performed for all funding types. No significant differences in the perceptions of funding adequacy were found between female and male graduate students regardless of the type of support (data not shown).

Among graduate students, 60% (n = 1,056) agreed with the statement, "Another source of funding would have enabled me to participate more in career and professional development education." The survey allowed students to comment on their answer. A recurring theme was that Fellowships and Traineeships would have enabled them to participate more in career and professional development opportunities.³¹

Funding levels impact where and how graduate students live. Therefore, this study asked graduate students about the type of accommodation that most closely matches their situation. Table 3.3.3.2 shows that the majority of graduate students rent an apartment off campus and live with roommates. There are no major differences between female and male respondents. Visa holders (international students) are more likely to live on campus than U.S. citizens and permanent residents. This finding emphasizes the importance of creating a sense of belonging on campus, which can impact the decision as to whether an international graduate student will continue to contribute to the economic development of the United States or whether the student leaves the country.³²

Table 3.3.3.2. Graduate Students' Accommodation by Gender and Citizenship/Visa Status

Type of Residence	All (n=1,890*)	Female (n=1,017†)	Male (n=767‡)	Visa holders (n=370§)	U.S. Citizens and permanent residents (n=1,484◆)
Rent	91.0	90.3	92.3	97.3	89.5
Own	9.0	9.7	7.7	2.7	10.5
Apartment	79.0	79.2	78.5	89.1	76.6
House	21.0	20.8	21.5	10.9	23.4
On campus	9.1	8.9	8.6	18.3	6.5
Off campus	90.9	91.1	91.4	81.7	93.5
My parent(s)	2.8	2.8	2.9	0.8	3.1
Significant other	33.5	35.5	31.1	20.8	36.9
Roommates	36.0	33.9	39.4	52.3	31.7
Alone	24.5	25.0	22.9	17.5	26.3
Other family members	3.2	2.9	3.7	8.5	2.0

Note: In the above table, the largest n is reported for each group. For a breakdown of the number of responses, by each group, for every question, see below.

The n's reported below are the number of responses by each group for every question.

*n=1,885, 1,879, 1,880, 1,890

†n=1,006, 1,008, 1,011, 1,017

‡n=767, 762, 760, 763

§n=370, 366, 366, 365

◆=1,471, 1,472, 1,472, 1,484

3.3.4 International Research Experiences

The development of global competencies in STEM graduate education might be critical to innovation, competitiveness, and economic development in the increasingly international marketplace of chemistry and chemical engineering. National efforts attempt to develop a better understanding of the timing and duration of international research activities and the role of the faculty advisor and others in enabling graduate students to develop global competencies.^{33,34}

This study asked graduate students about their previous international research experiences and their current plans for engaging in research experiences outside of the United States. Data was analyzed focusing on U.S. citizens, permanent residents, and visa-holders.

Of graduate students who hold visas, 18%, 17%, and 35% have engaged in short-, medium-, and long-term research experiences outside of the United States, respectively. In contrast, only 9%, 4%, and 7% of non-visa-holders had engaged in short-, medium-, and long-term research experiences abroad, respectively, at the time of the survey (Table 3.3.4.1). It is likely that a significant number of visa-holders had research experience as part of their higher education in their home country, prior to starting graduate school in the United States. In addition, visa-holders have demonstrated flexibility, adaptability, and cultural openness by coming to the United States for their graduate school experience. Thus, visa-holders might also be more likely to engage in additional international experiences during graduate school in the United States.

This study asked graduate students about their current plans to engage in research experiences outside of the United States during graduate school, after graduate school, or at any point during

Table 3.3.4.1. Duration of Previous Research Experience Outside the United States by Residency Status.

	Visa holders (N=379)	U.S. Citizens and permanent residents (N=1,495)
Duration of experience outside the United States		
Short-term (up to 2 weeks, research experiences, conferences, workshops)	17.9	9.0
Medium-term (2–6 weeks, research experiences)	16.9	3.5
Long-term (2–12 months, research experiences)	35.4	6.9

Notes:

Other responses and N/A's were excluded

Visa holders: J-1 visa, F-1 visa, and H1-B visa

U.S. Citizens and permanent residents: U.S. native, naturalized, and permanent residents

their career. Of graduate students who hold visas, 24%, 23%, and 24% currently plan to engage in short-, medium-, and long-term research experiences outside of the United States, respectively. In contrast, 22%, 13%, and 12% of U.S. citizens and permanent residents currently plan to engage in short-, medium-, and long-term research experiences abroad, respectively, as of the time of the survey (Table 3.3.4.2). The data suggest that visa-holders are almost twice as likely as U.S. citizens and permanent residents to engage in future international research experiences if those require a commitment of more than two weeks. The 508 graduate students who have engaged in or plan to engage in international research experiences were asked “How do you expect international research experiences will help you professionally?” Each open-ended answer was assigned to one or more of eleven impact themes (Table. 3.3.4.3).

By far, expanding cultural awareness and the professional network were the top two anticipated impacts of international research experiences. One respondent shared, “More exposure to different living and working environments would help in career decision-making.” Responses such as, “It looks good on my CV,” were in the minority. Bias, cultural barriers, and harassment in the United States showed up in some responses, such as, “While international research experience will be useful to network with other scientists and to gain a broader knowledge of the field, I am primarily interested in leaving the U.S. due to the hostile environment I face as a trans woman in the U.S.”

Table 3.3.4.2. Duration of Planned Research Experience Outside the United States by Visa Status

	Visa holders (N=379)	U.S. Citizens and permanent residents (N=1,495)
Duration of experience outside the United States		
Short-term (up to 2 weeks, research experiences, conferences, workshops)	24.3	21.5
Medium-term (2–6 weeks, research experiences)	23.0	13.1
Long-term (2–12 months, research experiences)	24.3	12.2

Notes:

Other responses and N/A's were excluded

Visa holders: J-1 visa, F-1 visa, and H1-B visa

U.S. Citizens and permanent residents: U.S. native, naturalized, and permanent residents

Survey participants were asked whether they expect to be supported by friends/family and their research advisor if they were to engage in short-, medium-, or long-term research experiences abroad. For both groups, data in Figure 3.3.4.1. show that the expected support declined the longer the research experience. It was expected by 73%, 60%, and 44% of students that research advisors would be supportive of short-, medium-, and long-term research experiences, respectively. It was expected by 48%, 44%, and 38% of students that friends/family would be supportive of short-, medium-, and long-term research experiences, respectively.

3.3.5 Harassment

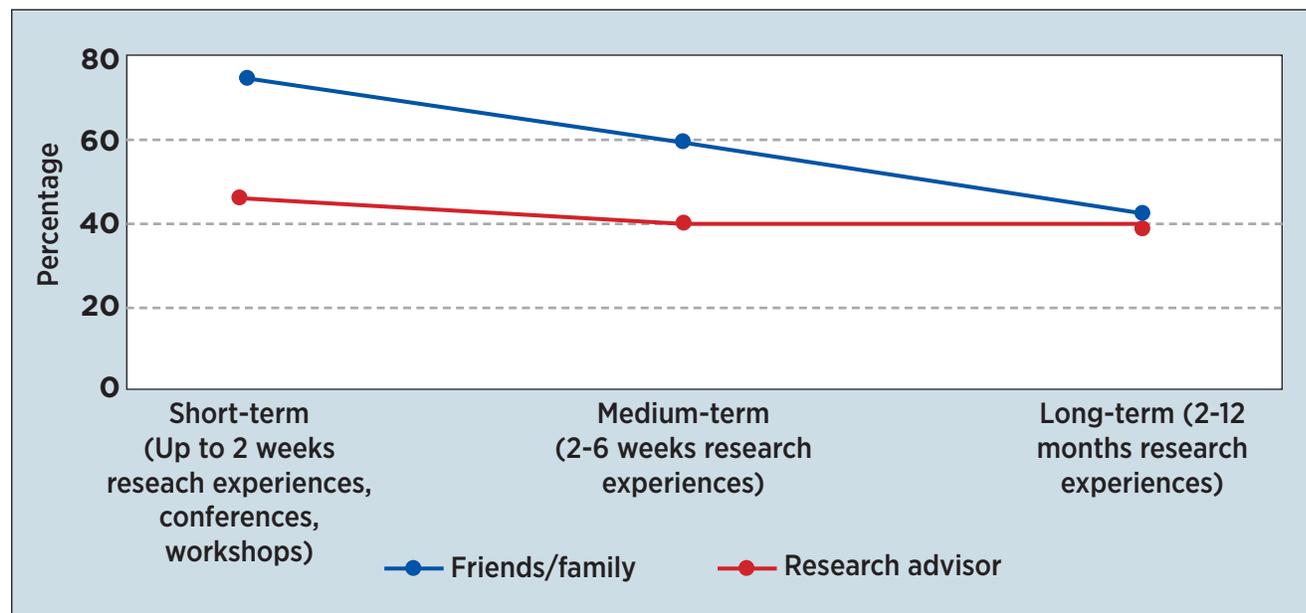
Nature's 2019 Ph.D. survey revealed that 21% of survey respondents from around the world experienced discrimination or harassment in their Ph.D. program.³⁵ Discrimination and harassment during graduate school can have a negative impact on mental wellness and performance.³⁶

The 2019 ACS Graduate Student Survey asked about “general” harassment that was defined in the survey as follows: “Harassment is a form of employment discrimination that violates Title VII of the Civil Rights Act of 1964, the Age Discrimination in Employment Act of 1967 (ADEA), and the Americans with Disabilities Act of 1990 (ADA). Harassment is unwelcome conduct that is based on race, color, religion, sex (including pregnancy), national origin, age (40 or older), disability or genetic information.” About 9% of graduate student respondents have experienced harassment (data not shown), while 7% were unsure, and 84% indicated that they had not experienced

Table 3.3.4.3. Expected Impact of International Research Experiences.

Expected impact	Number of responses
Becoming more culturally aware	216
Expanding the professional network	214
Acquiring new skills/knowledge	103
Growing personally	95
Starting or maintaining collaborations	66
Refining communication competencies	51
Demonstrating adaptability	20
Accessing unique resources	14
Advancing as mentor or mentee	11
Learning about new scientific fields	10
Other	48

Figure 3.3.4.1. Expected Support for Engaging in Research Experiences Abroad (n=738).



harassment at their institution since they started their graduate work. Data in table 3.3.5.1 show the results from all respondents and the differences for female and male survey respondents. About 18% of female respondents were possibly exposed to harassment at their current institution. In contrast, about 10% of their male peers possibly experienced harassment in graduate school.

According to the National Academies of Sciences, Engineering, and Medicine’s report on Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and Medicine³⁷ and other studies, “the cumulative effect of sexual harassment is a significant and costly loss of talent in academic science, engineering, and medicine, which has consequences for advancing the nation’s economic and social well-being and its overall public health.” This report includes among its recommendations that scientific societies increase their involvement in “helping to create culture changes that reduce or prevent the occurrence of sexual harassment” and “conduct necessary research.”

In an effort to understand the extent to which sexual harassment is experienced in graduate education in the chemical sciences, graduate students were asked, “...do you believe you have personally experienced any sexual harassment, as defined by USEEOC, at your institution?” As shown in Table 3.3.5.2, a significant portion of the survey respondents indicated that they believed they were sexually harassed. Not surprisingly, a significantly higher number of female respondents (9.5%) reported being harassed compared with the male respondents (2.9%). Additionally, about 5% of the students were unsure about having been harassed. To assess sexual harassment in vulnerable populations, a correlation was made between race and sexual harassment. The number of survey respondents did not allow for a comparison of all the races as different groups and thus, race was reported as Asian, White, and Underrepresented Groups, which includes American Indians or Alaskan Natives, Black or African Americans, and Native Hawaiian or other Pacific Islanders

Table 3.3.5.1. Experienced “General” Harassment

Responses	% of Total Number of Records		
	All (N=1,835)	Female respondents (n=992)	Male respondents (n=760)
Yes (verbal, physical, both)	8.5	10.7*	5.1
No	84.6	81.7	89.6
Unsure	6.9	7.7	5.3

*p<0.05

Table 3.3.5.2. Experienced Sexual Harassment, by Gender (N=1,785)

Responses	% of Total Number of Records		
	All (N=1,877)	Female respondents (n=1,020)	Male respondents (n=765)
Yes (verbal, physical, both)	7.2	9.5*	2.9
No	87.5	84.8	92.8
Unsure	5.3	5.7	4.3

*p<0.05

(Table 3.3.5.3). This correlation did not show any significant differences among students who reported having been harassed among the three groups.

Students who responded that they had been sexually harassed were asked about their actions in response to the harassment (Table 3.3.5.4). The majority of students responded that they told a colleague (25.1% of females and 22.5% of males) or a friend/family member outside of the organization (24.1% of females and 20.0% of males). However, 36.2% of students reported, “I kept quiet” as a result of the harassment (16.2% of females and 20.0% of males). Only 1.6% of the students responded that they left the organization because of sexual harassment. However, since we are surveying current graduate students, it is possible that the number of individuals leaving the organization as a result is higher. This study did not find any significant differences between the responses of female and male students.

Table 3.3.5.3. Experienced Sexual Harassment, by Race (N=1,799)

Race	Yes (verbal, physical, both)	No	Unsure
Asian (n=363)	4.1	87.3	8.5*
White (n=1,267)	7.7	88.4	3.9
Underrepresented Groups (n=99)	8.1	84.8	7.1

Underrepresented groups includes American Indians or Alaskan Natives, Black or African Americans, and Native Hawaiian or other Pacific Islanders

*A significant difference was found between Asian respondents and White respondents who selected “Unsure” (p=0.00192)

Table 3.3.5.4. Action Taken After Being Sexually Harassed, by Gender (N=231)

Response	% of Total Number of Records	
	Female respondents (n=191)	Male respondents (n=40)
I kept quiet	16.2	20.0
I told the harasser that this was wrong	11.0	17.5
I told a friend/family member outside of the organization	24.1	20.0
I told a colleague	25.1	22.5
I reported it to Human Resources/Management	9.9	7.5
I left the organization	1.6	0.0
I reported it to the authorities	2.6	5.0
I did not know what my options were	5.2	2.5
Other. Please specify	4.2	5.0

3.3.6 Resources and Benefits

Academic departments, divisions, and their corresponding institutions offer a wide array of resources that support the training, career, and professional development of graduate students. To learn about the availability and perceived usefulness of resources such as career seminars, internship support, safety training, and pedagogy workshops or seminars, graduate students were asked to indicate whether opportunities were available on their campus. If they had used the resource, students were asked to indicate whether they found the resource to be useful. (Table 3.3.6.1). Graduate student respondents came from 236 different institutions. If one student of any institution responded that they were aware of a resource, this study assumes that the resource is available on campus (e.g., 90.1% of institutions [n=236] had at least one student indicate that safety training was available). Responses show high availability and usefulness of campus resources focused on safety and TA training, and career and teaching/pedagogy seminars and workshops.

Table 3.3.6.1. Availability and Usefulness of Campus Resources

Resources	Percentage of institutions where resource is available*	Among students who report that this resource is available, percentage responding to the question: “If you used the resource, was it useful?”			
		“Yes”	“No”	“N/A”	n
Safety training	90.1	81.6	14.0	4.3	1,776
Graduate student orientation	86.6	61.6	30.4	8.0	1,686
Career counseling	85.1	23.5	16.4	60.0	1,429
Graduate student association	86.3	41.5	27.9	30.5	1,575
TA training	82.1	67.9	23.8	8.3	1,665
Teaching/pedagogy workshops	75.6	49.8	14.7	35.5	1,353
Job placement service	59.9	17.7	19.2	63.1	469
Career seminars/workshops	85.5	54.0	13.2	32.9	1,581
Chemistry graduate student organization	71.0	54.7	21.5	23.8	1,402
CV/resume review	85.9	30.7	15.8	53.5	1,395
Data on master’s degree and doctoral degree educational outcomes from previous research trainees of your department/institution	64.1	53.3	12.7	34.0	567
International research experience support	61.8	24.5	13.2	62.3	568
Internship support	65.6	23.2	18.4	58.4	591
On-campus counseling services (non—career related; e.g., mental health support)	87.4	35.1	16.1	48.8	1,661
Title IX Officer (knowledgeable about campus policies and procedures regarding sex discrimination and sexual misconduct)	86.3	39.3	13.6	47.1	1,568

*Indicates the percentage of institutions (N=262) represented among student respondents where at least one student indicated that, “Yes” this resource was available. For example, 90.1% of institutions (n=236) had at least one student indicate that safety training was available.

Graduate student orientations and graduate student associations (general and chemistry-specific) are also associated with high availability and usefulness. A large fraction of students indicated that they did not use or were not aware of campus resources such as career counseling, job placement services, CV/resume review, international research experience support, and internship support. More than 85% of campuses have non-career related counseling services (e.g., mental health counseling) and a Title IX Officer. Every educational institution must designate one employee who is responsible for coordinating the school's compliance with Title IX.³⁸ This indicates that graduate students are not aware of the availability of all resources on campus.

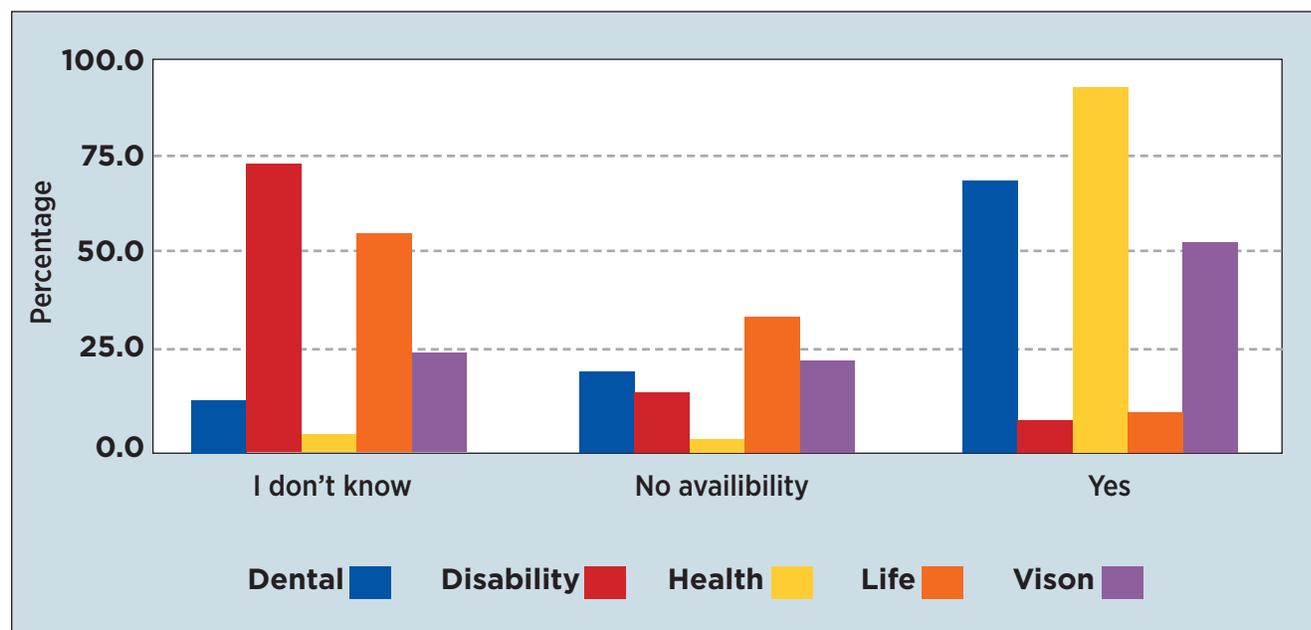
In comparison to results from the 2013 survey, awareness of campus resources such as safety training, graduate student orientation, career counseling, graduate student association, teacher assistant training, teaching/pedagogy workshops, and job placement services decreased 5–15%.

Graduate students were also asked about benefits offered by their institutions. As seen in Figure 3.3.6.2, almost all survey respondents were aware of the availability of health insurance, and about two-thirds of respondents were aware of the availability of vision and dental insurance. More than half of respondents were not aware of the availability of life or disability insurance.

To understand better whether students did not know about the availability of dental, health, life, and vision insurance on a campus or whether the institution did not offer these types of benefits, this study identified one university that was represented by 76 graduate student respondents. According to the institutional website, this university offers subsidized dental, health, life, and vision insurance to their graduate students (Table 3.3.6.3).

Survey respondents had the highest awareness of the availability of subsidized health insurance and the lowest awareness of life insurance. One reason for the overall low awareness might be that some graduate students have insurance coverage from other sources, i.e., through their parents, spouses, etc. Alternatively, institutions might inform students about insurance availability during the onboarding phase, when they receive a plethora of other information. Knowledge about available insurance might not only be helpful for students' own use, but also for their serving as a peer-mentor.

Figure 3.3.6.2. Graduate Students' Awareness of Insurance Types Available to Them at Their Current Institution



Leave times offered to graduate students often vary from one institution to another. Graduate students were asked about their knowledge of available leave times, such as maternity/paternity, sick, and vacation/annual leave, on their campus. About 60% of survey respondents indicated that they have access to annual leave, 15% indicated they do not, and 27% percent were unsure (Table 3.3.6.4). About a third of graduate students reported that they have access to maternity leave. When asked, “Are there any changes in benefits, including the addition of new benefits that you would like to see for graduate students?” 725 graduate students shared their thoughts.

Recurring themes suggest the need for:

- Transparent, regulated, and mandated leave policies
- Improved benefit packages (including retirement plans)
- Adjustment of stipend levels to reflect regional cost-of-living expenses
- Availability of “mental health breaks”

Table 3.3.6.3. Subsidized Insurance Offered by One Institution and Percentage of Its Graduate Student Survey Respondents Who Are Aware of Its Availability.

Type of insurance	Percentage of respondents who were aware of insurance availability (n = 76)
Dental	55.3
Health	61.8
Life	27.6
Vision	52.6

Table 3.3.6.4. Awareness of Leave Times Offered at Current Institution (n = 1,919)

Answer	Percentage of Responses		
	Is this leave time available at your current institution?		
	Yes	No	I don't know
Maternity/paternity leave (n=1,914)	31.5	9.4	59.1
Sick leave (n=1,917)	48.0	14.5	37.7
Vacation/annual leave (n=1,917)	58.0	15.1	27.0

3.3.7 ACS Membership

The American Chemical Society provides career and educational resources and in-person networking opportunities for its graduate student members.^{39,40} This study asked survey participants whether they are ACS members in order to assess whether there are differences in the perception of graduate students who are members of ACS and those who are not. Table 3.3.7.1 compares ACS members' and nonmembers' ratings of six survey items. Two survey items are associated with statistically significant differences. ACS members rated their preparedness level to make informed career decisions and their satisfaction with the overall graduate school experience higher than the non-ACS members. The cause for this significant difference is unknown.

Table 3.3.7.1. Comparison of ACS Members' and Nonmembers' Ratings

Survey Item	Mean (SD)	
	Member (n=1,347)	Nonmember (n=513)
Likelihood to complete degree program	4.68 (0.56)	4.59 (0.64)
Preparedness Level To Make Informed Career Decisions*	3.05 (0.98)	2.82 (0.99)
Confidence in ability to navigate the job market	2.98 (1.05)	2.90 (1.02)
Confidence in ability to build a successful career	3.25 (1.07)	3.15 (1.04)
Likelihood of remaining in chemical sciences after graduation	4.13 (0.93)	3.97 (1.01)
Satisfaction with Overall Graduate School Experience*	3.97 (1.00)	3.78 (1.17)

Each question was measured on a 5-point scale, with 1 being the worst rating and 5 being the best rating.

*p<0.05

4. Recommendations

The data gathered through the 2019 ACS Graduate Student Survey provide a snapshot of the graduate student experience, suggest opportunities for improving the quality of that experience, and also highlight the need for additional research. Overall, the majority of graduate student respondents reported that they are satisfied with their experience in graduate school and aim to pursue a career path in for-profit businesses such as industry. Master's and doctoral degree students feel confident that the core competency areas described by the National Academies Press report on *Graduate STEM Education for the 21st Century* (2018).¹ are elements that should be common among all STEM master's and doctoral degree programs. The interactions with and opportunities provided by their research advisors are largely viewed positively, the financial support and benefits are mostly deemed adequate, and the majority would not change their field of study. This survey also confirms that harassment (including sexual harassment) has been experienced by a number of graduate students in the chemical sciences and often remains unreported. The survey highlights the gap that exists in knowledge provided to respondents of information about a variety of careers, particularly nonacademic career paths.

The section below highlights recommendations for departments, universities, administrators, advisors and mentors, funders, professional organizations, and ACS to enhance the graduate student experience.

Recommendations Resulting From the 2019 ACS Graduate Student Survey:

- Conduct future surveys examining the values and socialization factors of graduate students in the chemical sciences that will allow for a multicultural lens to be focused on topics such as career motivation, advisor–advisee relationships, sense of belonging, intersectionality, and mentor–mentee relationships. These surveys have the potential to elucidate connections with socialization research done in other STEM and humanities fields, allowing for a convergence of cross-disciplines and of research, theory, and practice.
- Transparently disseminate and share real-time information with students and prospective students about the wide variety of career paths available to chemical scientists with graduate degrees, including current job market data, expected competencies for various positions, and career outcome data of alumni and alumnae, members, and others with chemical science degrees.
- Promote the importance of and implement activities that achieve diversity, inclusion, equity, and respect (DIER) for the students, faculty advisors, administrators, and staff within the graduate education community.
- Communicate the value and breadth of different career areas available to chemical scientists with master's and doctoral degrees, and provide programming that allows graduate students to explore different career areas and sectors. Ideally, the programming should be embedded in the curricula early in graduate students' experience.
- Communicate the value and expected core competencies associated with the acquisition of a graduate degree in the chemical sciences as described by the National Academies Press report on *Graduate STEM Education for the 21st Century* (2018).¹ Enhance graduate curricula to provide guided competency development activities that address communication, project management, pedagogical, and leadership skills.
- Communicate the value of available benefits, including career counseling resources, to graduate students.
- Promote and provide guidance for the use of Individual Development Plans (IDPs) with an intentional focus on the flexible, adaptable, and iterative nature of the IDP process. Programming associated with the IDP should allow for thorough self-assessment.
- Provide substantive resources (e.g., related training for students and faculty, mechanisms that encourage dialogue and reporting, and supportive structures for vulnerable groups, etc.) to address and prevent harassment. A code of conduct should be shared with the graduate

education community. Clear guidelines for how to address behaviors associated with any kind of harassment and a commitment to accountability should be disseminated.

- Communicate the value of and provide access to experiential opportunities (e.g., internships, international research, teaching opportunities, broader impact opportunities, etc.) that can significantly enhance the personal and professional development of graduate students.

These recommendations are based on the findings of this survey within the contexts of recent reports on graduate education, the current job market climate, and potential collaborative endeavors among the stakeholders in the graduate education ecosystem (i.e., university and industry partners, department representatives, graduate student mentors and advisors, partner professional societies, graduate students, and ACS).

5. Future Directions

The 2019 ACS Graduate Student Survey provided a snapshot of what is working and what is not in graduate education in the chemical sciences in 2019. The results encourage more in-depth exploration of several topic areas. Between 2013 and 2018, on average, 45% of all graduate students in chemistry were masters' degree students.² However, only 9% of survey respondents were from this group. Thus, further research is needed to develop a better understanding of the state of the master's degree students in the chemical sciences. Although graduate students rated themselves highly for all core competencies, it is unclear what salient standard (if any) they are measuring themselves against, as well as whether the definition and meaning of each competency are well understood. Future studies that could help elucidate this issue would include factoring in the perspectives of research advisors and other mentors; in addition, they would probe the new perspectives gained by students who have recently joined the workforce along with, if possible, the views of their first employers. To help develop appropriate support mechanisms for funders, departments, universities, and the American Chemical Society, additional research ought to examine the motivation for, expected impact of, and perceived barriers to professional development experiences that would enhance graduate education, such as internships or research, teaching, or service experiences abroad.

One concerning trend among doctoral degree students is that, in comparison to 2013 survey data, 10% fewer indicated that they would "definitely complete" their degree. It is critical to understand the factors that impact doctoral degree completion.

A concerted effort needs to be made by stakeholders (including faculty advisors, graduate student leaders, career practitioners, administrators, staff, and associations) to change from the current and limited culture of disseminating career and professional development information to graduate students. The current culture embodies an environment where research advisors are the main conduit of career information and mentorship and where academic careers are often viewed as the main route for graduate students to lead successful and productive lives. A cultural shift is needed where different career areas for STEM Ph.D.s are valued and where graduate students have the chance to explore them through a variety of mentors and methods and so gain agency over their career. The objective would be to prioritize the needs of the next generation of graduate students and their ability to meet the demands of the ever-changing environment which they now face.

The data gathered through this survey should serve as a catalyst for conversations among the numerous stakeholders that impact and are impacted by graduate education in the United States. Listening to the voices of the graduate students is essential if we are to attract and retain talented colleagues in the chemical sciences.

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Appendix A, Survey Instrument

Please visit www.acs.org/ACS2019SurveyAppendixA to view the 2019 ACS Graduate Student Survey Instrument.

Appendix B, Additional Methodological Details

Final Survey Data Validation and Cleaning

Following the administration of the main survey after five months, a series of data validation and “cleaning” steps were conducted in order to prepare the data for analyses. First, to specify the institutions included in the sample, students’ responses to the question, “At which institution are you currently enrolled?” were examined. Respondents could mark their institution from an extensive drop-down menu of institutional names, or they could enter it in an open-ended comment box if their institution was not represented on the menu. A total of 183 students wrote in their institution’s name. Twenty-two responses (representing 16 institutions) were recoded to match institutions already on the list; an additional 69 U.S. institutions were new to the list. The final institutional count included 262 U.S. institutions.

This process was repeated with respondents who, in response to the question, “What is your primary field of study?” wrote in their field of study (n=124). Write-in responses for the most part were recoded to match existing fields on the accompanying drop-down survey menu. The final list included 19 unique fields of study plus an “other” category (which included primarily nonchemistry disciplines). (See Appendix D).

Prior to data analysis, missing values were examined to determine whether there was a pattern to the missing data. Over the course of the survey—from the first item to the last—882 individuals dropped out, which represents approximately 32% of the total sample. After examining the responses, it was determined that attrition happened throughout the survey and did not represent a consistent pattern related to individual characteristics or certain survey items. As the data analysis was limited to descriptive statistics, missing values were not imputed. Thus, all data reported represent the valid responses for a given question.

Further data cleaning included small modifications, such as recoding calendar years into “years of study” or “age.” Finally, questions that were to be rated on a 5-Point Likert Scale were converted to numerical values from 1–5. This allowed the mean and standard deviations to be calculated for select questions. For reporting purposes, the 5-Point Likert Scale nominal values are given instead of the numerical values.

Analyses of Subgroup Differences

In addition to looking at the responses from all students, differences among groups were calculated and tested for statistical significance. Specifically, they focused on differences by degree (master’s and doctoral) and differences by gender (male and female respondents). We also examined differences by gender in the student–advisor pair for questions involving student–advisor relationships and advisors’ behaviors. Additional comparative analyses, including examinations by year in program, age, citizenship status, and underrepresented racial/ethnic minority (URM) status, were conducted as deemed relevant.

In order to determine whether differences among groups were statistically significant, a number of statistical tests were used. Depending on the survey item, these included independent sample t-tests, z-tests for proportions, and/or Pearson’s chi-squared test for independence. For these tests, a p-value of less than .05 denoted statistical significance (the size of a given difference

also was considered to guide understanding of variation—however, effect sizes were not formally computed for the purpose of this report). Chi-squared tests were used primarily to determine whether responses across ordinal or nominal response categories were distributed differently among groups. To perform pairwise comparison among groups of two or more, pairwise Chi-squared tests were used. Z-tests were used to determine whether the proportion of responses for an item that had more than two response options differed among groups. Finally, when comparing means among groups, independent sample t-tests were used. Statistical tests were robust in the face of differing sample sizes. In the body of the report, all noted differences among groups are significant at $p < .05$.

Appendix C, List of Institutions

AK

Alaska Fairbanks, University of

AL

Alabama, University of, at Birmingham

Alabama, University of

Auburn University

AR

Arkansas, University of, at Little Rock

Arkansas, University of, Fayetteville

AZ

Arizona State University

Arizona, University of

CA

California Institute of Technology

California, University of, Berkeley

California, University of, Davis

California, University of, Irvine

California, University of, Los Angeles

California, University of, Merced

California, University of, Riverside

California, University of, San Diego

California, University of, Santa

Barbara California,

University of, Santa Cruz

San Diego State University

Scripps Research Institute

Southern California, University of

Stanford University

CO

Colorado School of Mines

Colorado State University

Colorado, University of, at Boulder

Northern Colorado, University of

CT

Connecticut, University of

Wesleyan University

Yale University

DC

George Washington University

Georgetown University

DE

Delaware, University of

FL

Central Florida, University of

Florida Atlantic University

Florida International University

Florida State University

Florida, University of

Miami, University of

South Florida, University of

GA

Emory University

Georgia Institute of Technology

Georgia, University of

HI

Hawaii, University of, at Manoa

IA

Iowa State University

Iowa, University of

ID

Idaho, University of

IL

Chicago, University of

Illinois Institute of Technology

Illinois, University of, at Chicago

Illinois, University of, at Urbana-
Champaign

Loyola University Chicago

Northwestern University

Southern Illinois University-

Carbondale

IN

Indiana University-Purdue

University Indianapolis

Indiana University, Bloomington

Notre Dame, University of

Purdue University

KS

Kansas State University

Kansas, University of

KY

Kentucky, University of

Louisville, University of

LA

Louisiana State University, Baton

Rouge

New Orleans, University of

Tulane University

MA

Boston College

Boston University

Brandeis University

Harvard University

Massachusetts Amherst,

University of

Massachusetts Boston,

University of

Massachusetts Institute of

Technology

Massachusetts Lowell, University

of

Northeastern University

Tufts University

Worcester Polytechnic Institute

MD

Johns Hopkins University

Maryland, University of, Baltimore
County

Maryland, University of, College Park

ME

Maine, University of

MI

Michigan State University

Michigan Technological University

Michigan, University of, Ann Arbor

Oakland University

Wayne State University

Western Michigan University

MN

Minnesota, University of, Twin Cities

MO

Missouri, University of, Columbia

Missouri, University of, Kansas City

Missouri, University of, Saint Louis

Missouri University of Science

Saint Louis University

Washington University

MS

Jackson State University

Mississippi State University

Mississippi, University of

Southern Mississippi, University of

MT

Montana State University

NC

Duke University

North Carolina State University

North Carolina, University of, at

Chapel Hill

North Carolina, University of, at

Greensboro

Wake Forest University

ND

North Dakota, University of

NE

Nebraska, University of, Lincoln

NH

Dartmouth College

New Hampshire, University of

NJ

New Jersey Institute of Technology
 Princeton University
 Rutgers, the State University of
 New Jersey, Newark
 Rutgers, the State University of
 New Jersey, New Brunswick
 Seton Hall University

NM

New Mexico Inst of Mining & Tech
 New Mexico State University
 New Mexico, University of

NV

Nevada, University of, Las Vegas

NY

City University of New York,
 Graduate Center
 Clarkson University
 Columbia University
 Cornell University
 New York State University, College
 of Environmental Science and
 Forestry
 New York University
 Rensselaer Polytechnic Institute
 Rochester, University of
 Rockefeller University, The
 State University of New York at
 Albany
 State University of New York at
 Binghamton
 State University of New York at
 Buffalo
 State University of New York at
 Stony Brook
 Syracuse University

OH

Akron, The University of
 Bowling Green State University
 Case Western Reserve University

Cincinnati, University of
 Cleveland State University
 Kent State University
 Miami University
 Ohio State University
 Ohio University
 Toledo, University of

OK

Oklahoma State University
 Oklahoma, University of
 Tulsa, University of

OR

Oregon State University
 Oregon, University of
 Portland State University

PA

Bryn Mawr College
 Carnegie Mellon University
 Drexel University
 Duquesne University
 Lehigh University
 Pennsylvania State University
 Pennsylvania, University of
 Pittsburgh, University of
 Sciences in Philadelphia,
 University of
 Temple University

RI

Brown University
 Rhode Island, University of

SC

Clemson University
 South Carolina, University of

SD

South Dakota State University
 South Dakota, University of

TN

Memphis, The University of
 Middle Tennessee State University
 Tennessee, University of, Knoxville

Vanderbilt University

TX

Baylor University
 Houston, University of
 North Texas, University of
 Rice University
 Southern Methodist University
 Texas A&M University
 Texas Christian University
 Texas Tech University
 Texas, University of, at Arlington
 Texas, University of, at Austin
 Texas, University of, at Dallas
 Texas, University of, at El Paso

UT

Brigham Young University
 Utah State University
 Utah, University of

VA

George Mason University
 Old Dominion University
 Virginia Commonwealth
 University
 Virginia Polytechnic Inst. & State Univ.
 Virginia, University of

VT

Vermont, University of

WA

Washington State University
 Washington, University of

WI

Marquette University
 Wisconsin, University of, Madison
 Wisconsin, University of,
 Milwaukee

WV

West Virginia University

WY

Wyoming, University of

Appendix D, Disaggregated Characteristics of Survey Sample

Table D.1. Demographic Description of the Sample

Survey Item	Percentage Marking Each Response
Are you a Master's or Doctoral degree student? (N=2,772)	
Master's degree	8.6
Doctoral degree	91.4
What is your gender identity? (N=1,862)	
Female	55.2
Male	41.6
Nonbinary/third gender	0.7
Prefer to self-describe	0.5
Prefer not to say	2.0
What is your citizenship or visa status? (N=1,891)	
U.S. native	74.0
U.S. naturalized citizen	2.7
U.S. permanent resident	2.3
Foreign student (F-1) visa	19.2
Other visa*	1.7
Are you of Hispanic or Latino/a origin or descent? (N=1,872)	
Yes	6.3
No	90.8
Prefer not to say	2.9
What is your racial background?† (N=1,815)	
American Indian/Alaskan Native	1.9
Asian	20.4
Black/African American	3.3
Native Hawaiian or other Pacific Islander	0.3
White	70.2
Other	4.0
What is the education level of your father? (N=1,839)	
HS diploma or less	21.8
Any undergraduate experience	42.4
Master's degree	20.0
Professional degree (M.D., J.D.)	7.3
Doctoral degree	7.3
Not applicable / unknown	1.3

Note: While 2,772 doctoral and master's degree students began the survey, there was evidence of gradual attrition throughout the survey, resulting in a loss of 882 respondents from the very first question to the last. The data in this table represent the valid percentage of respondents for each question. Percentages may not sum to 100 due to rounding.

* The "Other visa" category includes those who are in the United States with a J-1 or H1-B visa, as well as those who marked "other visa."

† Individuals who marked more than one racial category on the survey were placed into the least prevalent racial category for the purpose of analysis.

Table D.1. (continued), Demographic Description of the Sample

Survey Item	Percentage Marking Each Response
What is the education level of your mother? (N=1,836)	
HS diploma or less	19.3
Any undergraduate experience	51.5
Master's degree	20.0
Professional degree (M.D., J.D.)	4.9
Doctoral degree	3.6
Not applicable / unknown	0.6
What is your partnership status? (N=1,869)	
Single	59.7
Married/partnered	40.3
Is your partner in a STEM or related field?‡ (N=754)	
Yes	55.7
No	44.3
Do you have one or more dependent children? (N=1,851)	
At least one dependent	6.6
No dependents	93.4
Age of respondent at time of survey (N=1,792)	
23 or under	12.8
24	12.4
25	17.0
26	16.3
27	12.1
28	7.6
29	5.6
30	4.2
31-35	8.0
36 or older	3.9

‡ Includes only those who indicated that they were partnered or married. STEM stands for science, technology, engineering, and mathematics.

Table D.1. (continued), Demographic Description of the Sample

Survey Item	Percentage Marking Each Response
What is your primary field of study? (N=2,757)	
Agricultural/food chemistry	0.8
Analytical chemistry	10.6
Biochemistry	8.5
Chemical biology	6.2
Chemical education	1.7
Chemical engineering	3.6
Chemical toxicology	0.4
Colloid & surface chemistry	1.1
Computational chemistry	4.0
Electrochemistry	1.3
Environmental chemistry	3.2
General chemistry	1.1
Geochemistry	0.4
Inorganic chemistry	11.7
Materials chemistry	9.5
Medicinal/pharmaceutical chemistry	3.0
Nuclear chemistry	0.7
Organic chemistry	15.4
Physical chemistry	9.4
Theoretical chemistry	2.5
Others§	4.6
Not determined yet	0.5
Number of years enrolled in your current degree program (N=2,543)	
Doctoral degree students (n=2,336)	
One year	27.7
Two years	19.3
Three years	20.9
Four years	19.3
Five years	8.3
Six years	2.8
Seven or more years	1.6
Master's degree students (n=207)	
One year	59.4
Two years	24.2

Note: The data in this table represent the valid percentage of respondents for each question. Percentages may not sum to 100 due to rounding.

§ "Other" fields of study (asked as an open-ended response option in this survey question) include: astrochemistry; atmospheric, catalytic, clinical, cosmetic, and supramolecular chemistry; biotechnology; chemical oceanography; environmental science; marine natural products; engineering management; molecular biology; natural products; neuroscience; pharmaceutical sciences; synthetic biology; and toxicology.

Table D.1. (continued), Demographic Description of the Sample

Survey Item	Percentage Marking Each Response
Master's degree students (continued)	
Three years	8.2
Four years	1.0
Five or more years	7.2
Years of graduate study needed to complete your... (N=2,608)	
Doctoral degree students: Doctoral degree (n=2,400)	
Less than one year	11.8
One year	21.6
Two years	21.0
Three years	18.9
Four years	17.5
Five years	8.1
Six or more years	1.0
Master's degree students: Master's degree (n=208)	
Less than one year	38.9
One year	38.5
Two years	14.9
Three years	5.8
Four or more years	1.9
Asked of doctoral students only: Do you plan to do a postdoctoral position upon completion of your degree? (N=2,397)	
Yes	32.7
No	27.2
Unsure	40.1
Asked of master's degree students only: Do you plan to continue in a Ph.D. program upon completion of your master's degree? (N=217)	
Yes	42.9
No	28.6
Unsure	28.6
Are you currently in a research group? (N=2,086)	
Yes	94.6
No	5.4
Do you currently have a primary research advisor? (N=2,069)	
Yes, one advisor	85.0
Yes, two advisors	10.2
No (no advisor)	4.8

Appendix E, Supplemental Table

Table E.1. Percentage of Students Affiliated to a Research Group

	% of Total Number of Records (N=2,086)
Yes	94.6
No	5.4

Table E.2. Correlation Among Students' Top Considerations in Joining a Research Group

	Research					
Interest	Group	Area	Topic	Lab	Focus	Enjoy
0.44	0.35	0.20	0.18	0.16	0.16	0.15