NORC at the University of Chicago

Graduate Schools Respond to COVID-19:

PROMISING PATHWAYS TO INNOVATION AND SUSTAINABILITY IN STEM EDUCATION

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NORC at the University of Chicago

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INTRODUCTION

Innovation and reform in graduate education—from academic and research training to mental health and wellness of graduate students to the structure and relevance of programs—had long been topics of debate as 2020 dawned on college campuses.[1] With the penetration of COVID-19 in March 2020, however, change in graduate education could no longer be debated. It became the critical element in maintaining academic and research programs.

As the dimensions of the pandemic became apparent, one graduate education dean described the predicament shared by all: "The problem is, when you're in a situation that has no precedent...trying to figure out what the next steps are and when they should happen is unbelievably difficult. It is a unique kind of thing."

Economist Paul Romer's famous quote—"A crisis is a terrible thing to waste"[2]—has renewed currency today as university administrators confront the crisis of a lifetime for most of their institutions. As challenging as the current situation is, when looked at against the backdrop of decades of reflection and research on strategies for improving graduate education, the pandemic could introduce an unparalleled climate for innovation. Crises provide conditions favorable to creativity: urgency for change; openness to options previously viewed as unrealistic, too risky, or too difficult; and the need to eliminate unnecessary activities to focus on the critical ones.[3] While graduate schools across the country have been experimenting with various strategies for more than a decade, the silver lining of the pandemic may be that it offers a perfect storm of opportunity for innovation at the master's and doctoral level.

Recognizing this opportunity, a central goal of this study is to document the challenges posed by the pandemic and, critically, the creative strategies graduate schools employed during the crisis. Our research collected information on higher education activities designed to achieve three goals: stimulate the success of current and future STEM graduate students; sustain STEM graduate programs through and after the crisis subsides; and identify and share innovations with the potential to transform and improve graduate education in the future.

This white paper reports results of a survey that documented efforts to achieve these objectives. Conducted with graduate deans, this survey focused on challenges posed by the pandemic in three domains: ensuring student academic and research progress; providing for student health and well-being; and maintaining program sustainability. In addition, the survey collected information on innovative strategies that institutions employed during the crisis—some enabled by technology, some involving changes in policy, and some reflecting new practices or processes.

This white paper has four sections: a brief outline of the methods used to collect the data, a report of the challenges the pandemic posed to graduate institutions, a discussion of reported innovations, and suggestions for future research.

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1 Caramello, C. (2018). *Useful knowledge: An annotated bibliography of CGS publications.* Council of Graduate Schools; National Academies of Sciences, Engineering, and Medicine. (2018). *Graduate STEM education for the 21st century*. National Academies Press. https://doi.org/10.17226/25038; Weisbuch, R., Cassuto, L., Bruns, P., Butler, J. & Strouse, A. W. (2016). *Reforming doctoral education, 1990 to 2015: Recent Initiatives and future prospect.* Andrew W. Mellon Foundation. https://mellon.org/media/filer_public/35/32/3532f16c-20c4-4213-805d-356f85251a98/report-on-doctoral-education-reform_june-2016.pdf.

2 Rosenthal, J. (2009, July 31). On language: A terrible thing to waste. *The New York Times Magazine.* https://www.nytimes.com/2009/08/02/magazine/02FOB-onlanguage-t.html.

3 Chisholm-Burns, M. A. (2010). A crisis is a really terrible thing to waste. *American Journal of Pharmaceutical Education, 74*(2), 19. https://doi.org/10.5688/aj740219.

Section 1.

OVERVIEW OF THE METHODS

Section 1.
Overview of the Methods

This research was funded by Rapid Response Research (RAPID) grant number 2030148 by the Innovations in Graduate Education program in the Division of Graduate Education/Directorate of Education and Human Resources at the National Science Foundation (NSF), using funds from the Coronavirus Aid, Relief, and Economic Security (CARES) Act. The purpose was to survey senior graduate education officers to identify and document the challenges faced by science, technology, engineering, and mathematics (STEM) doctoral and master's programs and students and to understand innovations developed as institutions responded to the 2019 coronavirus disease (COVID-19) pandemic.

Participants

The sample was composed of 300 graduate STEM degree-producing U.S. institutions. A stratified purposeful sample was drawn by first removing any institution in which more than 40 percent of its graduate students were enrolled solely in distance education courses prior to the pandemic. This was important to ensure that we targeted institutions for which a pivot to online course delivery may have been more disruptive. We obtained a sample of 300, made up of 258 doctoral institutions that awarded the most STEM PhDs in 2018 according to the Survey of Earned Doctorates[4]; 27 master's-level institutions that awarded the most master's STEM degrees in 2018 according to the U.S. Department of Education[5]; and, in recognition of their importance in diversifying the STEM pipeline and professional ranks, an additional 15 historically Black colleges and universities (HBCUs) awarding the most STEM graduate degrees (master's and doctoral) in 2018 beyond the two HBCUs already included in the 257 selected doctoral institutions.[6] From each institution, we identified the graduate school dean (or individual in an analogous position) to represent their school and assembled their professional contact information.

Measures

During the first stage of survey development, NORC research staff conducted four in-depth interviews with graduate school deans chosen to ensure variation in institutional size and type. These interviews informed the items included in the final instrument. After developing the instrument, NORC conducted cognitive interviews with graduate deans from three institutions to test the instrument for language clarity and to ensure key topics were covered. Minor adjustments were made as a result of these cognitive interviews.

The final survey[7] captured information on the major challenges STEM graduate students and STEM graduate programs faced as a result of COVID-19 and the promising practices and innovations their institutions developed to address these issues. Specifically, the measures focused on the impact and innovations in three broad areas of STEM education:

(1) Graduate students' academic and research progress

(2) Graduate students' health and well-being

(3) Graduate programs' continuity and sustainability

Each section contained a series of closed-ended items to uncover the challenges, their resulting impact, and any innovations implemented or enhanced to address those challenges and to allow comparisons in responses across institution type. Each section also contained a series of open-ended items to further capture context and nuance not afforded by closed-ended items. In addition to topic-specific open-ended items, each section ended with the same item: "Regarding (insert topic area here), are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please identify them here."

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4 National Science Foundation. (2019). *Survey of earned doctorate* (Table 7: Doctorate-granting institutions, by state or location and major science and engineering fields of study: 2018). Available from https://ncses.nsf.gov/pubs/nsf20301/data-tables/.

5 U.S. Department of Education. (n.d.). *IPEDS: Integrated postsecondary education data system* [online database]. Available at https://nces.ed.gov/ipeds/. (Note: To ensure a focus on institutions that awarded master's degrees as their highest degree, we excluded any institutions that were technically classified as Masters institutions but that also awarded any STEM-related PhDs in 2018.)

6 See Footnote 5.

7 The full survey can be found in Appendix C.

Survey Administration and Responses

To maximize participation, NORC emailed a press release on July 1, 2020 to the full sample, higher education associations, and STEM discipline-specific associations detailing the scope and purpose of the study. The online, self-administered survey programmed in Qualtrics was conducted from July 8 to August 24, 2020. Initially, the deans were contacted by email and asked to complete the survey on behalf of their institutions. Weekly email reminders were sent to institutions that did not respond. All communications with sample members emphasized the voluntary and confidential nature of participation. Sample members were not offered an incentive, such as money or other tokens, to participate in the survey, but they were invited to the virtual convening for completion.

In total, representatives from 208 institutions participated in the survey, resulting in an overall response rate of 70 percent. Table 1 presents the characteristics of the institutional sample and and survey response information.

Analyses

We performed analyses to explore differences between the basic Carnegie Classifications (i.e., doctoral institutions with the highest and lower research activity, master's institutions, and special-focus institutions that award a high concentration of degrees in a single field or set of related fields, such as medical schools, medical centers, and schools of engineering) and by minority serving institution (MSI) status (i.e., yes/no). Differences by public versus private status among doctoral institutions with the highest research activity were also explored. Comparisons primarily were completed using nonparametric tests, including the Mann-Whitney U test and the Kruskal-Wallis test. We provide test statistics as well as effect sizes where we found a statistically significant difference. In addition, qualitative content analysis of open-ended items was done manually using inductive coding.

70%
Response rate of the 300 STEM-focused graduate institutions completing the survey.

White Paper and Virtual Convening

Following initial data collection and analyses, we compiled preliminary results into a white paper. The research team also organized a virtual convening where initial results could be further discussed and refined. Survey participants as well as selected leaders from professional associations and foundations with an interest in graduate education were provided with copies of the white paper and invited to participate in the convening, which was conducted via video conference on September 29 and 30, 2020.

The convening was structured around six broad topic areas, with three topics discussed each day; the convening's agenda is included as Appendix A. At the beginning of each day, Debra Stewart, principal investigator (PI), provided context for the day's discussion and an overview of the topics to be addressed. For each topic, a member of our research team first provided a short summary of initial findings from the survey then facilitated a discussion with three graduate deans representing a diversity of institutions, and finally fielded questions from other attendees. Specific discussion and reflection questions for each topic area were outlined in the white paper and distributed to participants prior to the convening; these are included in Appendix B.

Each convening session was recorded and transcribed, and, subsequently, reviewed and inductively coded. We then incorporated additional findings and insights from the convening into material from the initial working paper to produce this final white paper.

Table 1. Characteristics of Sampled Institutions

Institutional Characteristic	Sample		Respondents		Response Rate
	N	%	N	%	
Overall	300	100%	208	69%	70%
Sampling Category					
Doctoral	258	86%	185	89%	72%
Master's	27	9%	15	7%	56%
HBCU*	15	5%	8	4%	53%
Carnegie Classification					
Doctoral institutions, highest research activity	131	44%	100	48%	76%
Doctoral institutions, lower research activity	106	35%	73	35%	69%
Master's institutions	37	12%	19	9%	51%
Special-focus institutions (e.g., medical school)	26	9%	16	8%	62%
Other Characteristics					
Minority-serving institutions (HBCU, HSI, etc.)	74	25%	52	25%	70%
Public institutions	205	69%	158	76%	77%
Private institutions	94	31%	50	24%	53%
Region					
Northeast	85	28%	56	27%	66%
Midwest	63	21%	49	24%	78%
Southeast	66	22%	48	23%	73%
West	86	29%	55	26%	64%
Urbanicity					
Large city	118	39%	80	38%	68%
Small or midsize city	96	32%	72	35%	75%
Suburb	58	19%	39	19%	67%
Town or rural	28	9%	17	8%	61%

HBCU = Historically Black colleges and universities; HSI = Hispanic-serving institution.

*Two additional HBCUs were included within the doctoral institution sample, for a total of 17 HBCUs.

Section 2.

INSTITUTIONAL CHALLENGES IN THE FACE OF COVID-19

Section 2.
Institutional Challenges in the Face of COVID-19

The impact of COVID-19 on higher education goes beyond the disruption of in-person classroom and laboratory teaching. It extends to student health and well-being, including the potentially disproportionate impact on the most vulnerable student populations (e.g., international students, students with disabilities, and students with families), and to program continuity and sustainability, including not only the retention of current classes but also the recruitment of new classes. Although a central goal of this project was to identify and share innovations developed in response to COVID-19, understanding how and to what extent COVID-19 has impacted institutions and their students was an important first step in contextualizing the subsequent innovations. To that end, we asked institutions a series of questions about their immediate response to COVID-19 as well as their future planned activities, their perception of impact on their students, and the greatest challenges they face as a result of the pandemic.

Planning and Response

Prior to COVID-19, all but seven institutions reported having a crisis management plan. Over one-half (54 percent) found that plan to be very helpful, and an additional 39 percent found it to be somewhat helpful. Special-focus institutions were more likely than the three other Carnegie Classifications to report the plans as helpful.[8]

All but two responding institutions indicated that their institution had a central administration team or task force that developed the institutional response to COVID-19, and the majority of survey participants (74 percent) were themselves part of that team.

One graduate dean at the convening emphasized consistency in response. They put into place guiding principles that would inform decisions across departments so that all students, regardless of discipline, were treated equitably.

One concept discussed multiple times throughout the convening was how institutions view their graduate students. One graduate dean said plainly, "One of the principles we used is that graduate students are students first." Thinking of graduate students as students versus teaching assistants (TAs) or research assistants (RAs) impacts messaging sent and priorities. This graduate dean emphasized that because graduate students play multiple roles, it is critical to have someone at the "decision-making table" who really understands graduate education and the diversity of roles.

At the time of survey administration, 88 percent of institutions indicated that their graduate students would likely be on campus for some form of in-classroom instruction in the fall and the STEM laboratories would be open for PIs and graduate students, and 94 percent reported that STEM field work/research would be conducted.

One graduate dean mentioned during the convening that their institution relied heavily on its graduate council in planning for the fall semester. These are faculty who are most closely connected at the individual program level and able to gather intelligence on the needs of various students in various disciplines.

Graduate Student Academic and Research Progress

While the survey probed on academic progress items related to online learning, alternative grading, and student advising, one discussion in the convening focused on time extensions for students. One participating institution provided an automatic one-year tenure extension for tenure-track faculty; however, when graduate students requested the same automatic one-year extension, it was not granted largely because not all graduate students were in jeopardy of not finishing on time. This highlighted the differences among disciplines, as an extension would be less urgent for students doing theoretical or metadata analysis.

8 Kruskal-Wallis H test, χ^2 (df = 3) = 8.85, p = 0.031, η^2[H] = 0.03.

Online Learning, Alternative Grading, and Student Advising

In response to COVID-19, over one-half (57 percent) of responding institutions moved all of their in-person graduate courses to a remote/online format either in whole or in part. An additional 14 percent moved at least 90 percent of their courses to a remote/online format. Roughly 8 percent of institutions indicated that less than one-half of their graduate courses moved online in response to the pandemic.

In spite of the large proportion of graduate courses that moved online in response to COVID-19, nearly one-half of institutions (48 percent) rated their institution's technical capacity to provide online learning as only marginally or somewhat capable. Less than one in five institutions (18 percent) rated their institutions as fully capable of supporting online/distance learning. While non-MSIs were significantly more likely[9] to indicate they are fully capable of online instruction, there was no relationship between institutions' perceived capabilities and the proportion of graduate classes that moved online.

While the overwhelming majority of graduate courses moved online as a result of COVID-19 (see Section 3), institutions did acknowledge several obstacles for their students in transitioning to online learning as shown in Table 2. Among the most significant obstacles were completion of required learning activities like internships or practicums and access to reliable internet service. MSI institutions reported more significant obstacles than non-MSI institutions with regard to accessing reliable computer hardware and software.

Table 2. Percent Reporting a Major or Moderate Obstacle to Transitioning to Online Learning

Obstacles for Graduate Students Transitioning to Online Learning…	Overall	MSI Status	
		MSI	Non-MSI
Access to a reliable computer	19%	25%	17%
Access to other reliable computer hardware*	27%	36%	24%
Access to software*	26%	33%	24%
Access to reliable internet service	40%	46%	38%
Access to library resources	29%	37%	26%
Access to academic support services	22%	31%	19%
Completion of required learning activities (e.g., internship, practica)	77%	85%	74%

* Denotes statistically significant difference by MSI status, Mann-Whitney U test, $p < 0.05$.

MSI institutions reported more significant obstacles for their students with regard to accessing reliable computer hardware and software.

With the move to online or remote learning, 79 percent of institutions reported they temporarily offered a pass/fail grading system instead of traditional letter or percent grades; an additional 3 percent made switching to the pass/fail grading system mandatory. The overwhelming majority of schools (83 percent) also reported the pass/fail criteria for graduate students differed from that used for undergraduate students.

In addition to course delivery obstacles, participants reported challenges delivering graduate student advising and mentoring. Less than a quarter (24 percent) of institutions reported they agree that graduate students received consistent advising from graduate faculty during COVID-19, and even fewer (12 percent) said they agree that virtual advising is an adequate replacement for in-person contact.

9 Mann-Whitney *U* test, 21% non-MSI vs. 8% MSI, $U = 3273.5$, $p = 0.034$, $r = 0.147$.

Research Progress during COVID-19

The pandemic disrupted not only classroom learning, but also laboratory and field research. Just 7 percent of institutions reported that all laboratories remained open during COVID-19 with or without enhanced safety measures. Most institutions (79 percent) kept some of their STEM laboratories open in some capacity, while 14 percent reported that all laboratories and lab activity closed when the campus closed. One institution remarked that graduate students were allowed to return to the labs after they completed a 3-credit hour intensive COVID-19 course. Institutions varied in reports of their ability to use online, virtual, or distance formats to remain productive while labs were closed. A little less than one-half (42 percent) indicated they could use distance formats to a small extent, while a little more than one-half (56 percent) could use distance formats a moderate to a great extent. Only three institutions reported not being able to use distance formats for laboratory research at all.

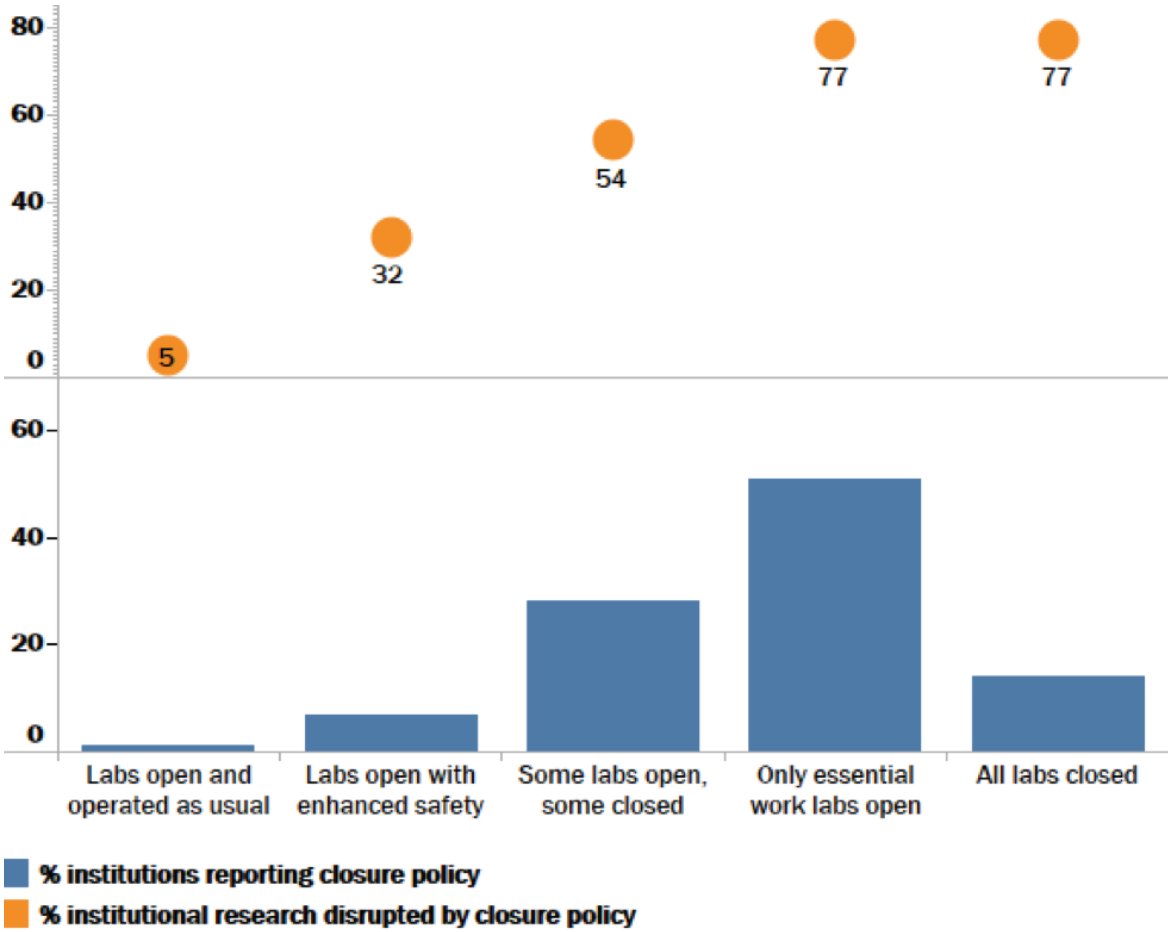
The way in which institutions opened their labs also impacted student research. Discussion at the convening expanded on these findings. At one institution, for example, lab staff could be in the lab for only a short window of time. These times were on rotation, so experiments could be conducted but analysis and writing had to be done later at home.

Discussion at the convening also further elucidated differences in research progress not only by fields, but also within fields.The basic biomedical sciences provide a good example. Students doing computational projects were able to continue their work from home; however, students doing wet lab experiments at the bench were dramatically impacted by lab closures.

On average, institutions reported 67 percent of their STEM research was delayed or discontinued due to COVID-19. As seen in Figure 1, however, the proportion of disrupted research varies considerably by the degree to which the institution's lab were open.

24%
reported graduate students received consistent advising from graduate faculty during COVID-19.

Figure 1. **Institutional Lab Closure Policy compared to Mean Proportion of Disrupted Research**



A little over two-thirds of institutions (68 percent) reported that some of their STEM graduate students were deemed essential workers for the purposes of maintaining laboratory or field research activities. Among those institutions, on average, 18 percent of graduate students were considered essential; however, the range varied from 1 to 100 percent of graduate students. Doctoral institutions with the highest research activity (80 percent) were significantly more likely[10] than doctoral institutions with lower research activity (61 percent) or master's institutions (37 percent) to have classified some of their graduate students as essential.[11] On average, doctoral institutions with the highest research activity did not, however, employ more graduate student essential workers compared with doctoral institutions with lower research activity and master's institutions. Most institutions (80 percent) did not provide hazard pay or extra compensation for these graduate students.

68% reported some STEM graduate students were deemed essential workers for maintaining laboratory or field research activities.

With 88 percent of institutions indicating their laboratories would be open in the fall for graduate students and 94 percent reporting graduate students would conduct field work in the fall, institutions were asked what safety measures they will require. All respondents indicated they would require social distancing and personal protective equipment for at least some of their graduate students, and all but seven institutions reported that personnel would be scheduled at alternating dates and times (see Table 3). We also asked institutions to share any additional COVID-19 safety-related precautions they are taking. Several mentioned monitoring symptoms, including temperature checks, submission of and adherence to a safety plan, COVID-19-specific safety training, and more frequent cleaning. One institution also reported that when they reopened their labs, it was voluntary for graduate students to return; the institution also included language around the power differential between professors and students.

Table 3. Percent of Institutions Implementing Safety Requirements as a Condition to Resume of Laboratory Activity and Field Work

Requirement in Place to Resume Lab/Field Work	Not Required	Labs Only	Field Work Only	Both Labs & Field Work
Limit number of personnel	--	14%	1%	86%
Schedule personnel to work on alternating dates/ times	4%	23%	1%	73%
Use of personal protective equipment	--	12%	1%	88%

Finally, we asked institutions if they have any mechanisms or processes (e.g., website, hotline, or ombudsperson office) that allow graduate students to confidentially or anonymously report actions or directives that could endanger an individual's health or safety. The majority (77 percent) had one in place prior to COVID-19, and an additional 12 percent implemented one at the onset of COVID-19.

Graduate Student Well-Being

With the understanding that students might respond differently if asked about their own well-being, this survey did ask graduate deans to report their perceptions of the impact COVID-19 had on various aspects of their graduate students' well-being. Feelings of loneliness was the most frequently reported concern (37 percent), followed by other mental health concerns (33 percent), physical health concerns (20 percent), food insecurity (14 percent), and access to housing (12 percent).

Many institutions at the convening emphasized the survey's finding of loneliness as a real concern for graduate students. Subsequently, graduate deans frequently discussed student communication. One graduate dean highlighted the importance of strategic communication: "It is critical to have your ear to the ground and anticipate concerns in advance of them becoming unmanageable challenges."

10 Chi-square, χ^2 (df = 3) = 16.14, p = 0.001, ϕ = 0.286.

11 Among special focus institutions, 69 percent reported classifying some STEM graduate students as essential. This did not differ significantly from the other three Carnegie types.

Given these concerns, it was important to learn if institutions were continuing to provide mental health services during the pandemic. Among responding institutions, all but two provided mental health services to graduate students prior to COVID-19, and among those, 96 percent continued those services to all graduate students in need. The remaining 4 percent reported that their continuing services were for graduate students in crisis only.

Vulnerable Graduate Student Populations

We asked institutions how COVID-19 has affected their vulnerable populations, including international graduate students, graduate students with families, and graduate students with disabilities. Institutional respondents reported that international students and students with families, in particular, faced considerable added pressures.

Travel restrictions—both the ability to return to their home country and the ability to re-enter the United States—were cited as having a large impact on the international graduate student population (68 and 81 percent, respectively) across participating institutions. A few respondents expanded on this in open-ended comments, with one institution leader indicating the international students' struggle with "feeling wanted and valued by [this] nation." Other areas having a large impact on international students include optional practical training (45 percent) and housing (26 percent).

The closure of day care facilities and schools have dramatically impacted students with families. Seventy-two percent cited child care and 70 percent cited home schooling as having the largest impact. Access to family health care was also cited as a concern (26 percent) but to a substantially smaller degree than child responsibilities.

The greatest reported impact on students with disabilities was decreased accessibility of community-based services (25 percent), followed by lack of accessibility to campus-based support services (19 percent).

Finally, we asked institutions if financial concerns resulting from COVID-19 have impacted more vulnerable graduate student groups. Institutions reported that international graduate students and graduate students with families have been impacted financially more than students with disabilities (45, 42, and 28 percent, respectively). Among the highest research doctoral institutions, public institutions were significantly more likely to report a large impact on international student finances compared with private institutions (58 versus 23 percent).[12]

International students and students with families, in particular, faced considerable added pressures from COVID-19.

One theme that repeatedly surfaced at the convening was the overlapping impact of COVID-19 and social inequities on graduate students. One dean stated, "The pandemic has especially hit communities of color and other groups of students that are currently underserved or underrepresented. These are the same groups that are hit by the disease load and also by the loss of like millions of positions across our economy. So how can we remain accessible with the funding models that we have where such a large part of the cost of the education is normally borne by the students?" Another dean, who also acknowledged the differential impact of COVID-19 on Black and Hispanic communities, noted that his institution created a pandemic health disparities fund to assist those students whose family members had been affected by COVID-19.

Institutional Finances and Program Continuity

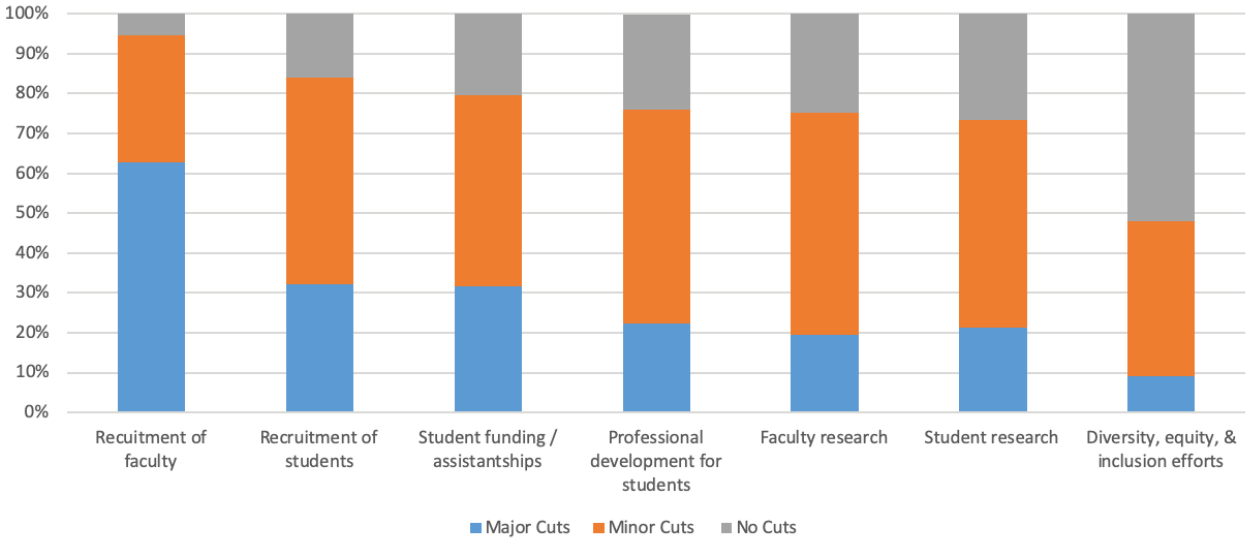
Budget Cuts

About two-thirds (67 percent) of institutions reported that they anticipate needing to cut the budget of their graduate school or programs (see Figure 2). Recruitment of faculty and students and student funding were the areas reported most likely to receive major budget cuts. Only seven institutions reported that there would be no cuts in faculty recruitment. Among schools in the highest research doctoral Carnegie Classification, public institutions were significantly more likely than private institutions to report major budget cuts to student funding/assistantships (21 versus 34 percent) and recruitment of faculty (46 versus 67 percent).[13]

12 Mann-Whitney $U = 453.5$, $p = 0.001$, $r = -0.34$.

13 Chi-square, χ^2 (df = 2) = 7.58, $p = 0.023$, $\phi = 0.352$ (student assistantships); chi-square, χ^2 ($df = 2$) = 7.91, $p = 0.019$, $\phi = 0.366$ (recruitment of faculty).

Figure 2. **Percent Reporting Budget Cut by Area**



67% of institutions anticipate budget cuts in their graduate school or graduate programs.

While the majority of institutions anticipated budget cuts in some areas, a smaller proportion anticipated substantial impacts on these areas. For example, while 84 percent reported at least minor budget cuts in student recruitment, just 17 percent of those anticipated a substantially smaller incoming fall 2020 class, and 8 percent anticipated a substantially smaller 2021 entering class. In fact, in all areas besides student recruitment, between one-half and 70 percent of institutions reported no anticipated impact.

Table 4. **Percent Reporting Impact of COVID-19 on Graduate Program Areas**

Graduate Program Area	Substantially or Somewhat Smaller	About the Same	Substantially or Somewhat Larger	Unknown / Undecided
The size of the Fall 2020 incoming class	52%	33%	13%	4%
The size of the Fall 2021 incoming class	37%	37%	19%	8%
The number of financial packages for students	41%	49%	6%	5%
The value of financial packages for students	19%	71%	8%	3%
The number of courses available to graduate students	22%	72%	4%	3%
The number of research assistantships available to graduate students	32%	64%	2%	3%
The number of teaching assistantships available to graduate students	32%	54%	10%	5%
The number of professional development opportunities for graduate students	28%	50%	21%	2%

There were some noteworthy differences by Carnegie Classification reported:

- Doctoral institutions with the highest research activity were significantly less likely than doctoral institutions with lower research activity to report that the value of financial packages would be smaller (10 and 45 percent, respectively).[14]
- Doctoral institutions with the highest research activity were significantly less likely than doctoral institutions with lower research activity to report that the number of available research assistantships would be smaller (28 compared to 49 percent, respectively).[15]

Admission and Retention

While more than one-half of institutions were anticipating at least a somewhat smaller incoming class in 2020, the majority reported no anticipated effect due to COVID-related changes in their admissions process on racial and ethnic diversity (56 percent), gender diversity (76 percent), and the overall strength (73 percent) of incoming students, as shown in Table 5. Among those that anticipated an effect, slightly more institutions anticipated a negative effect in each of these areas. Responses were a little more mixed with regard to impact on the socioeconomic diversity of their incoming students. Just under one-half (49 percent) reported no effect on socioeconomic diversity, with an additional 37 percent reporting a negative effect and 14 percent reporting a positive effect. Institutions that reported they would have fewer financial aid packages for students were more likely to report a negative effect on their socioeconomic diversity.

Most institutions anticipate no effect from COVID-19 on the racial/ethnic diversity, gender diversity, or the overall strength of incoming students.

For some institutions, the smaller incoming class was self-imposed out of necessity. One graduate dean at the convening discussed the balance many departments were trying to strike between admitting a cohort large enough to meet their academic model (e.g., for mentoring) while ensuring that the needed financial support was available.

Another issue regarding admission that was raised during the convening was how to support incoming international students who would not be able to travel to the United States for the start of the fall semester. This became particularly complicated for institutions at which graduate student employees were unionized. For many, this required real coalition building within institutions to navigate the complex systems of laws governing these processes.

Table 5. Percent Reporting Anticipated Effect to Incoming Class Characteristics

Incoming Class Characteristic	Negative Effect	No Effect	Positive Effect
Racial/ethnic diversity	27%	56%	17%
Gender diversity	12%	76%	12%
Socioeconomic diversity	37%	49%	14%
Overall strength of students	15%	73%	12%

Over three-quarters of institutions (79 percent) anticipated their orientation for new students this fall would be entirely online. Just two institutions reported it would be entirely in-person. The rest were a hybrid of online and in-person or dependent on department. After the threat of COVID-19 has passed, institutions anticipate change in how orientation will be conducted. About two-thirds (65 percent) reported they conducted their orientation completely in-person before COVID-19.[16] Among those, 77 percent reported they will move to a mixture of online and in-person post-COVID-19. Just 16 percent will return to an entirely in-person orientation.

14 Kruskal-Wallis H test, χ^2 (df= 3) = 11.168, p = 0.011, η^2[H] = 0.041.

15 Kruskal-Wallis H test, χ^2 (df = 3) = 11.548, p = 0.009, η^2[H] = 0.043.

16 In addition, one institution (<1 percent) reported it was entirely online; 24 percent reported a mixture of online and in-person, and the remaining 11 percent reported that it varied by department.

Along with anticipating a smaller incoming class, institutions at the time of survey administration also anticipated a decrease in retention of current students. Overall, 32 percent forecast a moderate decrease of domestic student retention (one institution anticipated a large decrease). Over three-quarters anticipated a decrease in international student retention: 24 percent anticipated a large decrease, and an additional 54 percent anticipated a moderate decrease. Master's and doctoral institutions with lower research activity were almost twice as likely to report that they anticipated a large decrease in international student retention (33 percent for each) when compared with doctoral institutions with the highest research activity (19 percent).[17]

Over three-quarters of institutions anticipated a large or moderate decrease in international student retention.

During the convening, there were mixed reports about whether and to what extent the pandemic was delaying the progress or graduation of graduate students. Although some deans reported very low rates of delays, other deans noted that their enrollment numbers had actually increased in part because more students were choosing to remain in school. It will be important to monitor and assess the ongoing effect of COVID on retention, graduation, and time to degree statistics.

One dean summarized the numerous issues associated with recruiting and retaining graduate students during (and after) the pandemic as an ongoing struggle to "right-size our graduate programs for the needs of our nation moving forward."

Job Placements for Graduates

The overwhelming majority of institutions reported that there will be fewer placements for graduating students as shown in Table 6.

Table 6. Percent Reporting Change in Job Placements for Graduating Students

Graduating Student Type	Significantly Fewer	Slightly Fewer	No Impact	Slightly More	Significantly More
Master's students	22%	62%	13%	3%	--
PhD students in positions within academia	55%	36%	7%	2%	--
PhD students in positions outside of academia	18%	60%	16%	4%	2%

Most reported that the impact on job placements would not disproportionately affect certain fields. For both master's and doctoral graduates, just 18 percent and 16 percent of respondents, respectively, indicated that certain STEM fields have been negatively impacted more than others. Engineering was the most frequently reported field to be disproportionately affected for master's graduates. The most cited fields for disruptions in PhD graduate placements were a little more varied; however, positions in academia and those requiring field work were cited by multiple respondents. Graduate deans at the convening also discussed the impact on professional programs, such as nursing, that require practicum or clinical hours that could not be done in person because of COVID-19 restrictions.

COVID-19 has disproportionately impacted not only certain programs, but also certain graduate student subgroups, particularly international students and students of color. One graduate dean commented, "The pre-existing disparities that were there before the pandemic have been amplified." This can be seen in the job market. International students and students of color have very similar concerns about their job prospects and "how welcoming the society is to them."

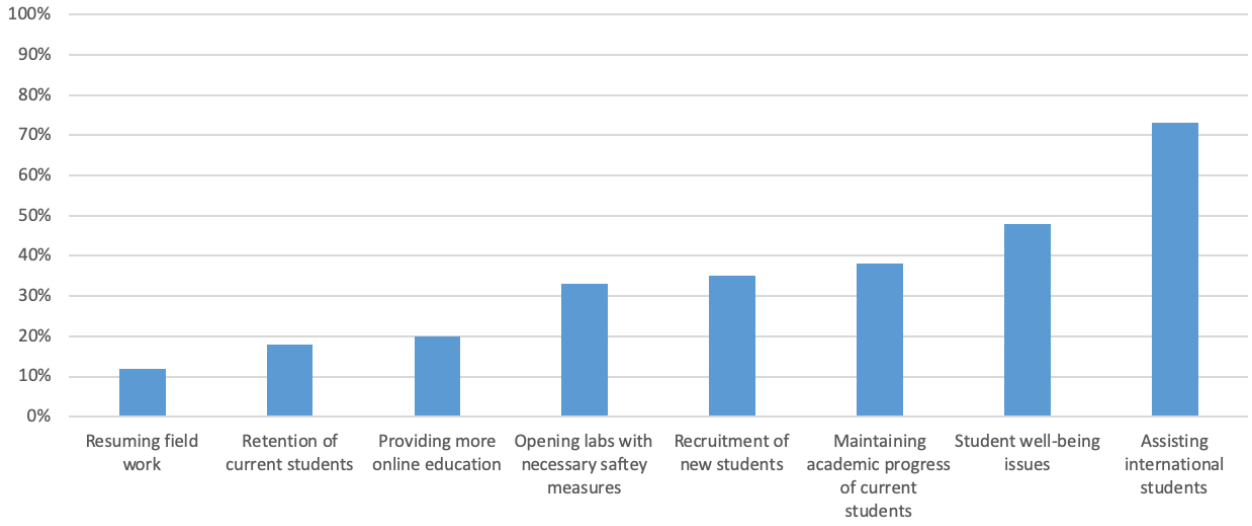
17 Overall, about 80 percent of institutions indicated both that at least a few of their students chose to delay their program completion and at least a few were forced to delay their program completion.

At the convening, one of several graduate deans stressed the importance of developing "better relationships with our partners in the community and industry so as to make sure that the graduate programs we offer are delivering [graduates] with the expertise that is needed in our nation post-pandemic" and "to prepare our students for the career pathways that they actually land in."

Final Thoughts on Institutional Challenges

We asked institutional respondents what they believed would be the top three challenges in the 2020-21 academic year (see Figure 3). The most frequently cited item was assisting international students, which was named in the top three by 73 percent of respondents. Issues of student well-being (48 percent) and maintaining the academic progress of current students (38 percent) ranked second and third, respectively. There were no differences by Carnegie Classification or MSI status with regard to these rankings.

Figure 3. Percent of Institutions Ranking Each Challenge in the Top 3 Challenges for 2020-21



Institutions indicated that the effects of COVID-19 will be felt not just in this academic year but also in 2021-22. Overall, 79 percent of institutions reported that COVID-19 will have at least a somewhat negative impact on their STEM graduate programs in the 2021-22 academic year and beyond. Table 7 identifies some reasons institutional respondents gave for explaining how COVID-19 would affect institutions moving forward.

Table 7. **Comments About Perceived Future Impact of COVID-19 on STEM Graduate Programs**

Anticipated Effect of COVID-19 in 2021 and Beyond	Corresponding Comment
Extremely negative	COVID-19 will have an extremely negative impact due to the shutdown of nonessential research labs. Students and faculty have lost time (not to mention millions of dollars in animals and reagents). This will have a systemic impact on our graduate programs and research profiles.
Negative	• Loss of time in the lab and slow down frustrated students and left them feeling "behind." Recruitment of students for the incoming class will be negatively impacted and the ability to recruit for next year will be difficult. • Budget cuts associated with declining tuition revenue and state funding will significantly reduce the number of assistantships we can award. We also froze hiring so the number of new faculty we have coming in is significantly smaller, reducing graduate opportunities. Depending on what happens with ruling about international students and online courses, we are questioning the ethical aspects of matriculating any international students (would it be in their best interest or not).
Somewhat negative	I do not think all virtual education is currently at the same quality as our in-person courses. I am confident this gap will diminish however. In addition, lab work with COVID safety measures in place is clearly less efficient than pre-COVID, so the experiential educational area will also be adversely impacted for some time to come. Finally, the potential negative impact on the mental health of students and mentors has the possibility to take this from a somewhat negative to a severely negative impact.
No impact	Eventually we will recover and rebound. Public health and biomedical science programs may even get a boost from increased research funding and interest.
Somewhat positive	We are making many small changes that COVID-19 has helped us promote, though the changes were underway prior. The crisis has awakened quite a few to seeking a new way.
Extremely positive/positive	We have been forced to think out of our comfort zone and COVID-19 required extreme changes which will be lasting. Without COVID-19 these changes would have been evolutionary.

79% reported that COVID-19 will have at least a somewhat negative impact on their STEM graduate programs in 2021 and beyond.

Section 3.

INNOVATIONS SPURRED BY COVID-19

Section 3.
Innovations Spurred by COVID-19

Identifying and sharing innovations developed by universities in response to the COVID-19 pandemic was a central goal of this project. More specifically, this study asked graduate deans and leaders to consider various areas associated with their graduate STEM programs and identify "new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future." Key findings fall into three broad areas:

(1) Academics and research activities

(2) Student health, well-being, and finances

(3) Retention and recruitment of graduate students and program sustainability

According to responses, innovations in (a) technology, (b) policy, and (c) practice have been identified and summarized.

Innovations in Academics and Research Activities

Technological Innovations

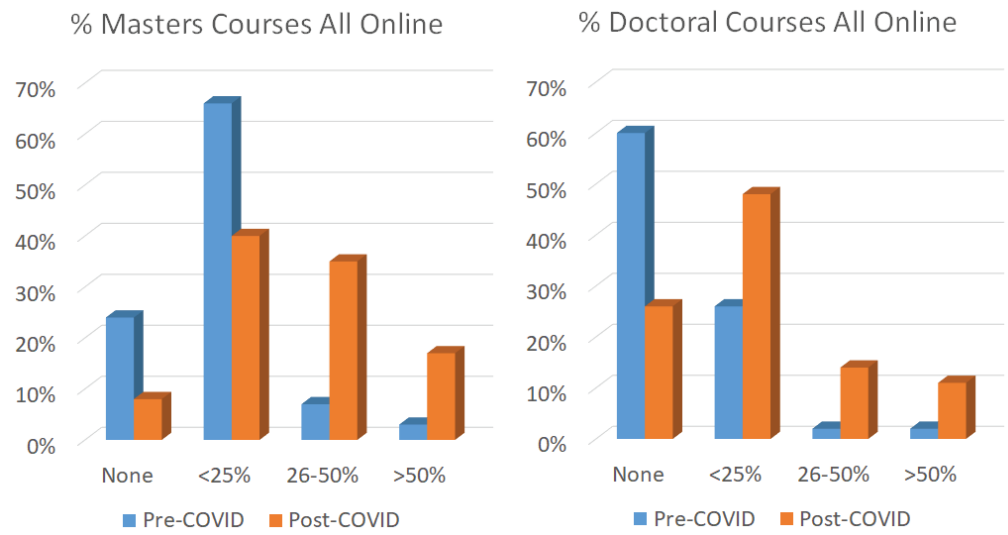
The most obvious and apparent innovation that virtually all graduate programs used in response to the pandemic was a shift toward online education for over 2.1 million graduate students, including more than 1.8 million who, prior to COVID-19, were enrolled solely in face-to-face courses and almost 275,000 who were enrolled in a mixture of in-person and online courses.[18]

According to survey results, the practical and strategic changes made by institutions in response to the pandemic will likely permanently shift the number of graduate students enrolled in online courses and programs. With regard to graduate courses, 94 percent of survey respondents reported that after the effects of COVID-19 have passed, their institutions would likely increase the number of classes offered in a hybrid format, and 83 percent would likely increase the number of courses conducted solely online. Further, with regard to graduate programs, more than three-quarters (82 percent) of the institutions anticipated expanding the number of programs offered in a hybrid format, and more than one-half (54 percent) anticipated expanding the number of graduate programs offered solely online after the pandemic has passed. Figure 4 illustrates these changes, showing the significant shift in the estimated proportion of courses conducted entirely online before and after COVID-19, both for master's and doctoral classes.

At the convening, several graduate deans noted that many institutions had begun implementing a number of online graduate programs—particularly at the master's level—prior to the pandemic, and these efforts often significantly boosted enrollment numbers. "What the pandemic has done," said one dean, "is, first of all, underscore the wisdom of developing online master's degrees. But secondly, it encouraged many units that have yet to develop online programming to start looking at that much more consistently."

18 U.S. Department of Education, National Center for Educational Statistics. (2019). *Digest of education statistics* (Table 311.15: Number and percentage of students enrolled in degree-granting postsecondary institutions, by distance education participation, location of student, level of enrollment, and control and level of institution: Fall 2017 and fall 2018). https://nces.ed.gov/programs/digest/d19/tables/dt19_311.15.asp?current=yes.

Figure 4. Proportion of Graduate Institutions Conducting Master's and Doctoral Courses Entirely Online, Before and After COVID-19*



*Denotes differences before and after COVID-19 were statistically significant both for Master's courses (Wilcoxon $Z = 9.199$, $p < 0.001$, $r = 0.432$) and for doctoral courses (Wilcoxon $Z = 8.391$, $p < 0.001$, $r = 0.429$).

83% will likely increase the number of online graduate courses after COVID-19 has passed.

To help with the mass transition to online education in spring 2020, 99 percent of responding institutions offered training for faculty, and 82 percent offered training to graduate TAs to help them teach effectively online; however, fewer institutions (70 percent) provided training or resources for students to learn better online.[19] In addition, 93 percent of institutions reported providing accommodations for students with disabilities to help them transition to online education, and 58 percent of institutions installed (or expanded) wifi hotspots around campus to provide greater internet access.[20]

Beyond simply switching to online delivery of their own courses, small numbers of institutions used other innovative strategies to deliver classes during the pandemic: 8 percent of institutions collaborated with other institutions on online courses, 6 percent used the services of an online program manager (OPM) to transition online, and 3 percent reported offering credit for students completing certain massive open online courses (MOOC). One respondent noted that, prior to COVID-19, faculty were very hesitant to transition their courses online, even though the institution had an OPM partner, but resistance fell following the pandemic because faculty realized that they could remain subject matter experts and allow the OPM to design and set up online versions of their courses. A number of institutions also wrote that they worked with offices or colleagues specifically charged with online teaching and learning initiatives on their own campuses to assist in transitioning graduate courses to virtual delivery.

Several institutions noted their plans to make added use of asynchronous learning elements in the future. One respondent noted: "Asynchronous modules will likely be used post-COVID-19 to partner with in-person experiences, [using] the asynchronous to support better learning when coupled with in-person, hands-on learning activities." Another wrote that the pandemic spurred further development and expansion of self-paced online courses, which could be used to supplement or complement face-to-face instruction, but could also be deployed on their own.

Numerous institutions also planned to expand the use of technology to better facilitate and enable advising and mentoring of graduate students. One respondent noted: "Faculty and students have become accustomed to video conference and chat for routine coaching, guidance, etc., as well as team meetings." Another stated: "We really did not use Zoom at all before mid-March, and now it is essential. We expect these technologies to be the new norm." In fact, many institutions found that online advising sessions were "easier to schedule and more efficient" and made it simple to conduct regular check-ins with graduate students to ensure they were progressing toward their degrees.

19 When analyzed by Carnegie class, significantly more doctoral institutions with the highest research activity (80 percent) offered training or resources to students to effectively learn online compared to master's institutions (44 percent); chi-square, χ^2 ($df = 3$) = 11.460, $p = 0.009$, $\phi = 0.246$.

20 When analyzed by Carnegie class, significantly fewer special-focus institutions (largely medical schools; 25 percent) provided wifi hotspots than doctoral institutions with the highest research activity (66 percent); chi-square, χ^2 ($df = 3$) = 9.998, $p = 0.019$, $\phi = 0.232$.

Beyond advising, several deans reported that teleconferencing technology has improved communications in other ways. For example, one dean at the convening reported that, before COVID-19, attendance at their institution's monthly graduate program director meetings was about 60 people, but after switching to virtual meetings during the pandemic, attendance has doubled and they are meeting more frequently, as well.

Institutions also found ways to use technology to facilitate research efforts. Numerous institutions noted the widespread use (and effectiveness) of virtual lab meetings, and one found that computational labs were able to seamlessly transition online with virtual collaboration. Others used video and computer-based interactions to enable and continue research and field work. Videoconferencing technologies were also used to conduct human subjects research. One institution reported using online technology to shift their entire graduate research conference online. In addition, the pandemic forced many faculty members to "become much more deliberate and thoughtful" about training graduate students to conduct research. "Before you were just there side by side in it, it just sort of happened. And now they really have to think about what does a student need to know? And how am I going to help them learn it?"

"We really did not use Zoom at all before mid-March, and now it is essential."

Several deans noted that technology enabled a greater expansion of professional development opportunities for graduate students. Switching to virtual delivery of such programs not only permitted graduate students to participate without having to come to campus, but multiple institutions reported opening up their professional development sessions to students at other institutions, thus dramatically expanding the reach and scope of such activities.

Innovations in Policy

During the pandemic, many institutions changed their policies and procedures to formally authorize the permanent expansion of many graduate programs into distance or virtual formats. As one dean said at the convening, "We actually implemented a number of policy changes that would allow units with on-campus graduate degrees to fast track the addition of an online version of that degree during the pandemic, with the full support of the Academic Senate on campus."

Beyond online teaching and learning, virtually all institutions amended their policies to authorize virtual and online processes for many other academic tasks. As shown in Table 8, during the pandemic nearly all graduate programs in our sample authorized and used online processes for dissertation proposals (99 percent), dissertation defenses (99 percent), thesis defenses (98 percent), doctoral exams (97 percent), and qualifying exams (94 percent)—practices that had been used by fewer than one in five graduate schools before the pandemic. Nearly four in five institutions (79 percent) adopted remote methods of proctoring exams. Nearly two-thirds of institutions automatically extended timelines for degree completion for all doctoral students (65 percent) and master's students (61 percent), and numerous additional institutional representatives clarified that their institutions granted such extensions on a case-by-case basis (and often quite liberally).

Table 8. **Adoption of Academic Policies and Practices in Response to (and Prior to) COVID-19**

Academic Policies and Practices	Allowed in Response to COVID	Allowed Prior to COVID	Total
Online dissertation defenses	84%	15%	99%
Online dissertation proposals	82%	17%	99%
Online thesis defenses	85%	14%	98%
Online doctoral exams	87%	10%	97%
Online qualifying exams	85%*	9%	94%
Remote proctoring of exams	63%	16%	79%
Automatically extend timeline for completion for PhD students	65%	6%	71%
Automatically extend timeline for completion for master's students	61%	7%	68%

Note: Individual values may not add up to the total due to rounding.

*When analyzed by Carnegie class, doctoral institutions with the highest research activity (87 percent) were significantly more likely to allow online administration of qualifying exams in response to COVID-19 than master's institutions (59 percent); chi square, χ^2 (6) = 21.827, p = 0.001, ϕ = 0.232.

With regard to research practices, a number of institutions revised and updated their laboratory continuity policies and contingency plans, as well as policies governing essential workers. Institutions also changed policies on scheduling of lab personnel to de-densify labs.

To continue research, some institutions noted that they had to engage in "creative thinking about what constitutes research in STEM, e.g., systematic review, meta-analysis." Another institution introduced "a rapid internal grant competition for innovative research projects on COVID-19-related topics. This was very successful, and we will be doing more of these in the future (we have already done a second, focused on studies related to increasing URM participation in research)." Other institutions made new arrangements with outside partners. For example, one institution arranged for its lab-based students to assist the state health department with COVID-19 testing, and another expanded its outside research and clinical partners to de-densify sites and find new opportunities for students whose prior placements were ended due to COVID-19.

Respondents identified numerous other academic policy changes that authorized or established:

- Digital forms, files, signatures, and paperwork, with many noting added efficiency
- Online course evaluation
- Recording of classes (generally via videoconferencing platforms) to assist students who were unable to participate and students who wished to review classroom discussions or topics
- Student academic leave of absence policies (both new or revised)
- Loosening of requirements for in-person attendance
- Virtual participation of external dissertation committee members

Although expanding the use of digital forms may seem a relatively minor adjustment, it can actually have a quite profound impact. For example, one dean at the convening shared how his institution converted their system for reporting the results of doctoral exams into a digital process, which automatically notified appropriate students, faculty, and staff of the outcome. In addition, the process provided a simple and easy mechanism for completing necessary follow-up actions. This process thus produced two benefits: it freed up faculty and staff to handle more pressing and important matters, and it created an immediate record of the exam results and any subsequent changes or follow-up,

Similarly, expanding leave policies for students may also provide important benefits. Not only do such policies help during the pandemic—allowing graduate students to "get through this current crisis healthy with their families and then come back to us," as one dean said—but also provide a mechanism for future students to navigate difficulties and crises that may arise.

Innovations in Practice

Institutions also identified a number of helpful adaptations in their academic and research practices during the pandemic. More than anything, several respondents noted the pandemic made institutions re-evaluate all of their practices by magnifying all the things that were not working well. In the words of one dean, COVID-19 made institutions focus on "why we are doing what we're doing," to figure out what was necessary and to change or do away with practices and procedures that were not useful.

One important development, noted by several respondents, was that the shift to online learning placed greater attention on and increased use of inclusive pedagogies (such as universal design for learning) for students with disabilities and other marginalized groups.

Another practice that gained traction during the pandemic was formative assessment. Just over one-half of respondents reported that they agree (14 percent) or somewhat agree (45 percent) that the coronavirus pandemic expanded the need for more regular and ongoing evaluation in graduate courses. One institution noted they were recommending that professors "embed student learning assessments within every lecture." Another noted that online platforms and educational technologies contain analytics that can allow professors to "more precisely" track student performance "because it left footprints of data in relation to assignments, responses, and engagement in general." Another respondent noted that faculty were using transcripts from videoconferencing platforms like Zoom to give feedback to graduate students following academic presentations like, oral examinations, proposals, and defenses.

Over one-half believe that the coronavirus pandemic expanded the need for more regular and ongoing evaluation in graduate courses.

Within the research realm, institutions adopted numerous practices to limit virus exposure and allow for greater social distancing in labs and field work sites. One respondent said, "The same people were scheduled in the lab for every shift, creating 'pandemic pods' and limiting exposure to too many different people. This has helped cohesion and morale. It has motivated students and faculty to observe the public health rules and keep each other safe." These "pandemic pods" have proven so successful, in fact, that the institution plans to keep them after the pandemic passes "because we have found that those smaller pockets of students who are always using the lab, at the same time, actually become good friends. And it's a way for them to develop belonging and relationships on campus. So that was sort of something we happened upon that we're really excited about."

Another dean noted the pandemic will lead them to take a more "hands-on approach to assigning lab rotations" for its first-year graduate students. Other respondents acknowledged networking with other institutions to help secure and share online and virtual services for field work, testing, and other research efforts.

Interestingly, only 14 percent of institutions reported COVID-19 had spurred increased efforts to reduce graduate student dependence on faculty and PIs for funding, research opportunities, and academic progress. One respondent noted that graduate schools need to "re-think student-faculty relationships" and "alter the research dynamic to give students more say in what they study." Another institutional representative noted the pandemic highlighted the need for faculty to receive more training in mentoring and advising.

Scheduling "pandemic pods" in research labs limited exposure, helped cohesion and morale, and motivated students and faculty to keep each other safe.

It is also important to recognize, however, that despite the utility of online and other technologies in enabling teaching and learning, there is a trade-off. "What we haven't figured out how to replace," said one dean at the convening, is "the 'accidental' learning that often happens or should happen as part of a doctoral program. I know if I think back to my own interactions that I had with my fellow students, and just helping them with maybe some of their field work or just talking about things. And to me that's probably the biggest loss and the hardest thing to replace technologically."

Although institutions developed and used a number of innovative practices to facilitate student learning and research during the pandemic, perhaps the most consequential change was the simplest: "The faculty were kind and forgiving. The human component of caring about students as human beings cannot be underestimated."

Innovations in Student Health, Well-Being, and Finances

Technological Innovations

Numerous institutions noted the widespread use of telehealth to provide graduate students with health and wellness support during the pandemic. Indeed, as reported in Section 2, of the 99 percent of respondents whose institutions provided counseling services to graduate students prior to the pandemic, all continued to provide services during the pandemic, with 96 percent providing access for all graduate students and the remaining 4 percent providing services for graduate students in crisis.[21] Telehealth was used for counseling, group therapy, and medical services. However, the state law in at least one institution's jurisdiction does not authorize or permit telehealth services for students who reside in other states, which restricts the efficacy of this solution. Other institutions noted that they used online technology to provide regular webinars for graduate students on mental health and wellness topics, including meditation and mindfulness sessions.

Online technology was also used to build community and support systems during COVID-19. One institution reported using its learning management system (LMS) to organize all of its graduate students into online "communities," which facilitated information sharing from the institution and interaction among the students themselves. Another institution developed a Slack channel[22] to "build a safe and private online community outside uncontrolled platforms like Facebook." Still another institution "instituted some virtual community building activities for affinity groups, such as a virtual 'homeroom' for international students just to check in."

Policy Innovations

A number of the policy innovations spurred by the pandemic were adopted to address the financial impact of COVID-19 on graduate students. Only a small fraction of graduate schools automatically extended funding for their students, with just 13 percent extending funding for master's students and 20 percent extending funding for doctoral students.[23] However, numerous respondents noted in open-ended responses that funding extensions were made on a case-by-case or department-by-department basis, and other respondents noted their institutions expanded and/or extended graduate student benefits such as health coverage.

There were also significant policy issues associated with funding international students, especially those who, as a result of the pandemic, would be residing outside of the United States (see Figure 5). Although about one-quarter of institutions (or more) indicated both domestic and international students residing in the United States would remain eligible for assistantship positions even if not physically present on campus, only 15 percent of institutions reported that international students residing abroad would be eligible for any type of assistantship.

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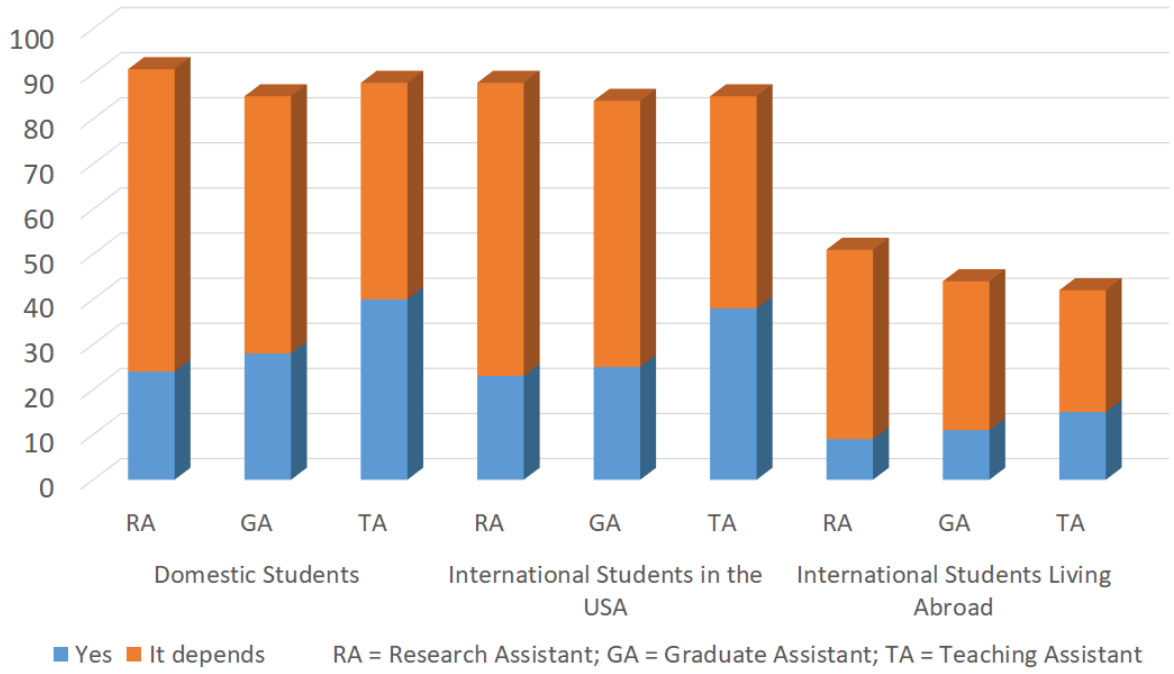
21 When analyzed by Carnegie class, significantly more doctoral institutions with the highest research activity (99 percent) continued to offer counseling services to all graduate students during the pandemic compared to master's institutions (83 percent), which were more likely to offer counseling only for graduate students in crisis (17 versus 1 percent); chi-square, χ^2 (df = 6) = 10.805, p = 0.013, ϕ = 0.234.

22 Slack is an online communication tool that allows organizations to set up chat rooms and private groups.

23 When analyzed by Carnegie class, specialty institutions (largely medical schools; 44 percent) were significantly more likely to automatically extend funding for PhD students than doctoral institutions with the highest research activity (12 percent); chi-square, χ^2 (df = 6) = 22.075, p = 0.001, ϕ = 0.236. It should also be noted that there were no significant differences in the proportion of institutions that automatically extended funding for either master's or doctoral students based on the public/private status of the institutions. This was true both within the overall sample population and within the group of doctoral institutions with the highest research activity.

Figure 5. **Eligibility for Assistantship Positions if Graduate Student Is Unwilling or Unable To Be Physically Present on Campus by International Status and Residence**



With regard to funding for international students living abroad, several respondents indicated they had developed innovative approaches to circumvent potential limitations associated with hiring/employing foreign students living outside of the United States by entering into sophisticated legal arrangements with a third party, such as Mauve (i.e., mauvegroup.com), which would hire and pay the students. These arrangements, however, were described as highly technical and expensive and involved complicated tax issues. Others simply converted assistantships into scholarships for international students. One dean of a public institution, however, noted that it was not politically feasible for them to even consider sending state money to students in foreign countries, even if they were enrolled at the institution.

Institutions took a variety of other approaches to address the financial needs of students during the pandemic. Several designed and adopted new types of assistantships to help with remote course design and delivery (e.g., "technical teaching assistantship" or "remote course facilitators"). Other institutions authorized payment of graduate students who participated in training for online teaching or extended assistantships from nine to 11 months.

Institutions also lowered fees and expenses for graduate students. One reduced the enrollment cost for students in candidacy; one waived health care fees for students over the summer; another removed surcharges and separate tuition rates for online courses; others allowed students to keep tuition and fee waivers even if enrolled in all online courses; another reported adopting courses that only ran for one-half of a semester; and one reduced fees for fully off-campus students. More dramatically, one institution reported that it would reduce the size of future cohorts to accommodate "the heterogeneous impact of COVID-19 on dissertation progress."

Institutions lowered fees and expenses for graduate students.

Other policy innovations provided greater mental health support and assistance to graduate students during the pandemic. One institution, which previously had a part-time counselor dedicated to graduate students, converted that position to full-time (even after the COVID-19 pandemic passes) and will house that professional within the graduate student services building on campus. Other campuses sought to increase mental health support by allowing graduate students to access their institution's employee assistant program or by providing graduate students with access to community-based mental health benefits. One campus authorized the institution's social work students (many of whom lost clinical placements as a result of the pandemic) to provide mental health services for graduate students. Other institutions indicated the pandemic helped them build deeper connections and cooperation with their campus student health and wellness partners.

Practice Innovations

Institutions used a number of practices to maintain a sense of community and student well-being within their graduate programs during COVID-19. Efforts implemented by at least three-quarters of all institutions included coordinating meetings about wellness (78 percent); increasing the frequency of communications (77 percent)[24]; and hosting virtual academic meetings (75 percent).[25] Two additional efforts used by at least one-half of respondents included coordinating support groups (58 percent)[26] and hosting virtual social events such as coffee breaks or happy hours (51 percent).[27] Other efforts to address the sense of community within graduate schools included the use of needs assessment surveys, meetings on potential unionization, and virtual town halls.

Institutions used a variety of practices to support the needs of graduate students during the pandemic, such as keeping campus food pantries operational during the crisis and expanding on-campus childcare. One institution is designing a trauma-informed approach to graduate student services "that was motivated by the challenges students are having during COVID."

To help with student finances, one institution implemented a centralized process for providing funding for graduate students to attend or present at virtual conferences. Another institution increased its fundraising efforts specifically to provide additional assistance for need-based students, especially international students.

Most fundamental, however, was this advice for supporting students during the pandemic: "Increased communication— students really appreciate an authentic personal touch. It has to be real!! Relationships matter. Trusted people matter. It cannot be rote, boilerplate platitudes."

One institution is designing a "trauma-informed" approach to graduate student services "that was motivated by the challenges students are having during COVID."

Innovations in the Recruitment and Retention of Graduate Students and Program Sustainability

Technological Innovations

As in other areas, online and virtual tools were key innovations used by graduate institutions to recruit students (especially international students). Numerous institutions increasingly turned to online recruitment fairs, hosted virtual recruitment sessions and webinars, and held Zoom-enabled meetings with admitted and incoming students. One dean reported personally hosting an online information/Q&A session with over 450 admitted students, which the dean expects to continue post-pandemic.

Several institutions entered collaborations with technology partners to assist with recruitment. One institution is having an outside firm develop a digital recruitment platform for them and several others substantially increased their digital market budgets. Another institution hired a third party to design a ChatBot powered by artificial intelligence that will be able to answer over 500 common questions about the institution; this new program will be accessible to applicants as well as admitted and current students. The ChatBot will also include a text messaging interface.

Several institutions noted that they were looking to strategically develop more online programs to help increase enrollments. One institution, for example, prioritized expanding online options in programs with large numbers of international students, who may be less likely to be able to enter the United States or attend class on campus. Another institution is working with some of its smaller graduate programs—programs that had previously resisted online options—to explore virtual options as a way of expanding the size and sustainability of those programs.

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24 When analyzed by MSI-status, significantly fewer MSIs (65 percent) increased communications during the pandemic compared to institutions not designed as MSIs (81 percent); chi-square, χ^2 (df = 1) = 5.200, p = 0.023, ϕ = 0.158.

25 When analyzed by Carnegie Classification, special-focus institutions (largely medical schools, 100 percent) and doctoral institutions with the highest research activity (82 percent) were both significantly more likely to conduct virtual academic meetings than doctoral institutions with lower research activity (63 percent); chi-square, χ^2 (df = 3) = 16.273, p = 0.001, ϕ = 0.280.

26 When analyzed by Carnegie Classification, special-focus institutions (largely medical schools, 88 percent) were significantly more likely to coordinate student support groups than master's institutions (37 percent); chi-square, χ^2 (df = 3) = 10.607, p = 0.014, ϕ = 0.226.

27 When analyzed by Carnegie Classification, doctoral institutions with the highest research activity (61 percent) were significantly more likely to coordinate virtual social events than master's institutions (16 percent); chi-square, χ^2 (df = 3) = 15.076, p = 0.002, ϕ = 0.269. When analyzed by MSI-status, significantly fewer MSIs (39 percent) coordinated virtual social events during the pandemic compared to institutions not designed as MSIs (55 percent); chi-square, χ^2 (df = 1) = 40.07, p = 0.045, ϕ = 0.139.

Innovations in Policy

Large proportions of institutions modified their admissions policies in light of the COVID-19 restrictions, as seen in Table 9. At least one-half of all institutional respondents reported engaging in virtual interviews, expanding consideration of pass/fail courses, extending application deadlines, and waiving both standardized tests and on-campus visits or interviews. Forty percent of institutions expanded their use of holistic review during the admissions process (in addition to the 40 percent who had already adopted this process prior to COVID-19).

40% expanded their use of holistic review processes during the admissions process.

Although only a fraction of institutions (17 percent) reported waiving English proficiency exams, a number of respondents noted in comments they accepted alternative methods of determining proficiency, with Duolingo mentioned multiple times. Further, one dean at the convening made the point that requiring English proficiency exams may exclude students they actually wish to recruit: "Not just because it's expensive, or because it might require preparation that students aren't able to do, but because it's a mental or psychological hurdle as well [and because] our data show that the success of a student in the STEM program is really more dependent on their personal resilience, the social support they have, and the motivation that brings them into the program."

Table 9. Modifications to Admissions Policies in Response to COVID-19

Admissions Policy	Changed in Response to COVID	Allowed Prior to COVID	Total
Conducted virtual interviews	68%	16%	84%
Expanded consideration of pass/fail or credit/no credit courses	64%	2%	66%
Extended application deadline	59%	4%	63%
Waived standardized tests (GRE, etc.)	55%	17%	72%
Waived campus visits/interviews	55%	12%	67%
Expanded holistic review	40%	40%	80%
Waived English proficiency exams	17%*	2%	19%

Note: Individual values may not add up to the total due to rounding.

* When analyzed by Carnegie Classification, master's institutions (41 percent) were significantly more likely to waive English proficiency exams in response to COVID-19 than doctoral institutions with the highest research activity (12 percent); chi-square, χ^2 (df = 9) = 19.450, p = 0.022, ϕ = 0.182.

Institutions also adopted other innovative policies to assist with the recruitment and retention of graduate students—particularly international students, who faced many additional hurdles given travel restrictions during the pandemic. These policies included entering into strategic partnerships with global entities and partners to assist international recruitment efforts. One institution decided to review and evaluate transcripts from certain international institutions themselves, rather than relying on an external agency, as most of their international students came from a small set of institutions and securing third-party verifications created unnecessary administrative and financial hurdles for applicants. Another survey respondent reported their institution hired its continuing international students to serve as "global ambassador peer mentors," which was expected both to improve retention of current international students by providing them needed funding and to assist in the recruitment of new international students.

Some institutions implemented formal admissions deferral policies, adopted academic leave of absence policies, and extended deadlines for both applications and time to degree. One institution marketed a "free fee day," which allowed students to apply without an application fee and generated a large number of highly competitive candidates. Another innovative effort to secure new students included offering full scholarships to incoming students to enroll in summer classes.

Innovations in Practice

Institutions reported making considerably greater efforts to recruit and retain graduate students during the COVID-19 crisis. In fact, nearly one-third (32 percent) of institutions reported engaging in substantially more effort to ensure newly admitted graduate students would enroll at their institution this fall, and nearly one-half (48 percent) had engaged in somewhat more effort to secure the enrollment of admitted students. As one dean explained: "Faculty got much more engaged, they knew it was dynamic and tense, so they increased their efforts to increase certainty." Institutions reported developing and implementing detailed communications plans for incoming (and returning) students, appointing "virtual buddies" for admitted students, and ensuring faculty had weekly online office hours just for recruited students (especially international students).

"Faculty got much more engaged [in recruitment], they knew it was dynamic and tense, so they increased their efforts to increase certainty."

Multiple institutions tracked which continuing students had yet to register for fall courses and "then contacted those students to offer assistance and encouragement." Other institutions provided lists of admitted students who had yet to enroll to program directors, who personally followed up with the students to encourage them to enroll.

Many institutions also took efforts to recruit graduating seniors at their own institutions. For example, one institution sent postcards to undergraduates with high GPAs to inform them of graduate options, several were looking to develop more accelerated degree programs, and one created scholarships for its graduating seniors to enroll in its master's programs at substantially reduced rates. Other institutions targeted recruitment efforts at institutions with a larger number of international undergraduates with the hope of alleviating visa issues.

Multiple institutions also noted that the pandemic situation forced them to review and reform their curricula. One institution, for example, decided to eliminate many "specializations" that were offered, deciding instead to focus on the core competencies that all graduate students would need. Another institution noted that the pandemic's impact on the economy and career opportunities reinforced the need of STEM graduates "to combine technical skills with soft skills so as to broaden career options." Another institutional representative noted that the changes resulting from COVID-19 emphasized the importance and need to "get people out of disciplinary silos" and engage in more trans- and interdisciplinary research.

Several institutional representatives highlighted the importance of communication and engagement between programs and their students. "The programs doing the best," one dean reported, "are the ones who are finding ways, on their own, to do outreach to and engagement with their graduate students." Another wrote: "We preach open and frequent communication all the time and don't necessarily even follow our own advice, even though a vast majority of our challenges could have been averted with good communication. COVID has proven this out in a real time experiment. We had weekly communiques from the dean, we encouraged regular communication between students and course directors and mentors. We were relentless in messaging regular communication and frankly it paid off and in many ways we had much fewer problems than might have normally arisen."

Finally, a number of institutional respondents noted the pandemic highlighted broader issues of social and racial justice that persist on campus, particularly in STEM fields. "[T]he interaction of anti-Black racism, white privilege in graduate education, and the differential impact of COVID-19 by race, ethnicity, and socioeconomic status... is the major issue going forward in my view." Stated another: "Parallel with the impacts of COVID-19 has been a rise in awareness of social justice issues....I think that the impact of the latter on this campus and on STEM fields will be significant and perhaps obscure the effects of COVID." These issues demand attention and focused response: "There is a need for an absolute rededication to social justice, the awareness of structural inequalities in academe and elite institutions in particular, and the lack of diversity among the faculty. In this rededication, white folks need to commit to humility and responsibility for structural inequalities—and how that informs our environments, collaborations, etc....That has all been laid bare by...COVID and other crises."

Sustaining Innovation

One of the most important issues addressed at the convening was how universities could sustain innovation after COVID-19 has passed. Beyond addressing how to best preserve or institutionalize specific changes made during the pandemic, graduate deans were also wrestling with how they could sustain the drive to continue transforming graduate education into the future.

"I think universities will definitely be changed forever," stated one graduate dean. "If they're not, I will be bitterly disappointed because this is an opportunity that we need to leverage to improve higher education and to improve graduate education."

Another dean shared: "Graduate students are in the spotlight in ways they haven't been before. I think there's been an assumption that graduate students are kind of part of the fabric, and the teaching gets done, and the research gets done, and there's this little army of people who somehow managed to make a contribution. But we've had more conversations about graduate student mental health, about graduate student food insecurity, about housing insecurity, about mentoring and abusive mentoring than I've heard in a very, very long time.... The iron is really hot right now. Graduate students are front and center. And I think it behooves us to try and keep that iron hot and keep them front and center as best we can."

During this discussion, deans identified three key areas in which changes are most likely to continue after the COVID-19 crisis.

Transforming the "Intellectual Space" of Graduate Education

Because of the "cataclysmic and devastating" impact of the pandemic, one dean expects fundamental transformations in the academic heart of graduate education: "The intellectual space is going to change around what our students are asking and how they're asking the questions." Based on the discussion at the convening, these shifts will likely be apparent in a number of ways.

First, the pandemic will likely alter the very subject matter of research and inquiry. "The interplay of all of the impacts from the pandemic and all of the changes that the world has experienced" will shape the direction of intellectual inquiry across all fields, both in and outside STEM.

Second, the broader debates and discussion surrounding COVID-19 have prompted many in the scientific community to expand the focus away from "pure" research and instead include "a greater interest in public-facing science and increased commitment to communicating science."

Third, given ongoing debates about the "truth" surrounding COVID-19 and the safety of potential vaccines, scholars and institutions are likely to place a renewed emphasis on the responsible and ethical conduct of research.

Fourth, deans noted that the scope and impact of the pandemic—which has personal, social, international, economic, medical, and scientific implications (among others)—demand greater use and acceptance of interdisciplinary and transdisciplinary work. This, they hope, will produce increased "permeability across departments and fields." Widespread acceptance and use of virtual technologies, they believe, can facilitate such intellectual collaborations.

Finally, the very structure of graduate education may change with institutions beginning to offer courses and credentials outside of traditional master's or doctoral paths. "I think there's another group of folks out there who are probably going to need us in the next few years. And it may behoove us to start thinking about how we reach out to those individuals, how we engage them, the kind of programming they're looking for.... This is an opportunity for us to open up the world of graduate education to people who would never have considered it as something that's potentially a part of their lives....I think there's probably a bunch of paying customers out there who'd be happy to come back and get a credential, and they might not want it to be called a master's degree. They might not want it to even be called a certificate. Maybe it's a badge."

Aligning Policies and Practices

A second area of graduate education that will likely undergo continuous and lasting change concerns the alignment of policies and practices. As noted in earlier, COVID-19 was like a magnifying glass, highlighting policies and practices that were outdated, unneeded, or unfair. The pandemic has thus provided graduate school leaders an important opportunity to step back, re-examine, and reconsider their operations.

Some of these changes will be relatively straightforward and directly address the changes needed during the pandemic; for example "ask[ing] whether their policies that were written for a face-to-face world will transcend and work in a virtual space." But in doing so, deans emphasized that simply shifting practices to an online or virtual format may not sufficiently replace face-to-face learning. Graduate schools must find ways to better incorporate the "informal, yet important aspects of the learning environment" in online settings, perhaps through more intentional use of smaller project teams or interactive projects between students. "With people not being on campus together, interacting in both formal and informal spaces, I think there's a lot of that cross-cultural learning that's going to be lost.... I fear our students will leave our institutions with terrific technical skills and maybe some halfway decent communication skills, but not with those really humanistic skills that allow them to understand and appreciate people who aren't like them and don't share their lived experience."

One dean recommended that, when reviewing policies and practices, graduate schools should focus on core principles. "I often ask the question, why [do] we have some of the policies? And if I can't come up with the answer, then it's about time to [make] a change…. We base our policies on some kind of principles. And the principles may not vary, but how the policies are written might. And I want to bring up a doctoral residency as an example…. I think it's time to revisit that less about how long and where, but how they can achieve the principles underlying the residency. So I think one of our tasks right now is to take a look at our policies, understand what our principles are, and make those adjustments."

Issues of policy and practice, however, also implicate deeper, more profound issues of fairness and equity. "The students have come to us and asked us, 'Well, now that we're in this pandemic mode, we're all seeing what each other is doing in a different way. Why do I have to do this and this student doesn't have to do this.' So we're confronting those issues individually and asking their degree of being actionable…. The other piece of this is that if [policies are] not clear, some people will be in the club and they will understand the meaning and some people will not be in the club. And historically, that cleave has come to create inequities for women and for students from historically underrepresented groups who may not feel as comfortable or as included in these conversations. So we're facing this and engaging what we can do to stimulate faculty to move in directions that will open up discussions about aligning policies and practices systematically."

Practicing Inclusion

Last, but perhaps most important, one of the most powerful and recurring themes from the convening was the need for graduate institutions and their leaders to be more inclusive and just.

At a practical level, inclusivity is required to make any innovation or change stick. "That's one of the things I think we often forget on our campuses. We think about students and faculty, and we don't necessarily think about that glue that tends to hold programs together…. We come up with this fabulous idea that faculty love and students love, but the staff who actually have to push the button and make it go [say], 'Whoa, we can't do it that way.' And so I think, you know, another lesson learned from this experience, and one that I hope will stick is the idea that we're a university community that consists of students, faculty, and staff, and that we need to engage their voices when we make these changes."

More fundamentally, however, the pandemic clearly exposed the ongoing presence of systematic racial and social injustice, not just in society at large, but on campuses as well. One dean explained that during the summer of 2020, which saw ongoing protests after the high-profile killings of two Black people, George Floyd and Breonna Taylor, by police, "we had some students that were afraid to come to campus because of insecurity around police protection and racial injustice, and so when students got to campus, they felt very safe. It was a space between their home and arriving on campus, and perhaps being stopped. So all of these conversations about [coordinating times for graduate students to come to campus during the pandemic] increased the sense of understanding vulnerabilities in the context of the full impact of the pandemic, and the layering of racial equity and social justice, and safety."

"The interaction of anti-Black racism, white privilege in graduate education, and the differential impact of COVID-19 by race, ethnicity, and socioeconomic status is the major issue going forward."

Section 4.

NEXT STEPS IN RESEARCH ON THE IMPACT OF COVID-19 ON STEM GRADUATE EDUCATION

Section 4.
Next Steps in Research on the Impact of COVID-19 on STEM Graduate Education

This project, funded under the NSF RAPID program, was true to its funding intent. It proceeded with extraordinary speed to document the challenges posed by the COVID-19 pandemic to graduate education and to illuminate strategies the universities employed to respond to those challenges. Through a series of expert interviews, a comprehensive national survey, and the virtual convening, this research paints a detailed picture of the actions taken by U.S. graduate schools as they attempted to ensure STEM graduate students continued to make academic and research progress and sustained some level of well-being, and that graduate programs sustained themselves through this pandemic.

As with any research project, this work has limitations. First, the project was begun and completed while the pandemic was still ongoing. Although we designed the survey instrument to capture both initial responses and perspectives on actions in the future, deans completed the surveys while graduate schools remained, in the words of one convening participant, "in the eye of the storm." Thus, it provides a "moment in time" understanding of the experience.

A second limitation is that the primary data source was the individual who served in the position with administrative oversight of master's and doctoral programs in STEM fields on each campus. These university officials are ideal informants because they have the most direct knowledge of how problems were defined and solutions developed. Another critical perspective, however, is that of graduate students themselves—how they experienced the pandemic and the efforts the graduate school initiated to alleviate its impact on them. This research does not capture that perspective. Fortunately, other work is currently providing that critical student insight, most notably in a companion project funded under the NSF RAPID program and led by Craig Ogilvie at Montana State University.

Finally, the survey design was virtually completed by the time the response to the deaths of George Floyd in Minneapolis and Breonna Taylor in Louisville—both Black people killed during police arrest procedures—was unfolding. These produced a dramatic national escalation in awareness of racial inequality in the United States. Racial equality and social justice issues inevitably intervened to impact the pandemic experience for graduate students of color. Although both the survey instrument and the convening inquired about differential impacts due to race, ethnicity, and socioeconomic status, a more in-depth and targeted analysis is needed.

Recognizing these limitations and thinking about the most effective way to build on our research in the future, we suggest four new research directions to address these gaps and explore other key issues that arose from our study.

Sustaining Promising Practices in STEM Graduate Education: An Assessment of Pandemic-Generated Innovations

U.S. graduate schools have been called on to innovate for decades. Our RAPID research indicates that as graduate schools struggled to respond to the challenges of COVID-19, they simultaneously innovated on a variety of fronts. Sometimes the innovation was simply a dramatic acceleration of activity underway before COVID hit; sometimes it was the adoption of a practice in place elsewhere but never tried at a particular institution; and sometimes it was entirely new. But in every case, the innovations, while triggered by the crisis, attempted to move the practice of graduate education forward to meet previously unmet needs.

Data from our survey and the convening revealed a host of initiatives undertaken by graduate schools as they have tried to meet their students' needs to sustain academic progress, research progress, and essential well-being while simultaneously maintaining the health of their graduate programs. Although not all actions taken in response to COVID-19 are worthy of sustaining, many initiatives do count as notable improvements in graduate education that should and will be sustained, and their introduction was dramatically facilitated by the crisis. This research direction aims to highlight the most promising innovations and suggest a set of principles for nurturing and sustaining them in the future.

Racial Justice and the Pandemic: An Examination of Differential Impact of COVID-19 on Students of Color

The popular and the higher education press have routinely reported that students from underrepresented and underresourced populations are in a worse state due to the pandemic than their White and higher-income counterparts. University-focused studies have indicated that students of color and underresourced students are more likely to have housing and food insecurity, anxiety, and depression. Achieving more inclusive graduate programs—which has long been the STEM community's stated goal—will likely be more difficult to attain given the clear differential impacts of COVID-19.

To advance the goal of broadening participation and increasing the inclusivity of students and scholars of color, we must better understand the precise impact of COVID-19 on graduate students of color compared to their White peers at each stage of the graduate process—from admissions through graduation and into their careers. Researchers need to reflect on the optimal research strategy, considering whether a broad-based national survey, a carefully selected set of case studies, or some combination might effectively yield the necessary fine-grained information. Regardless of methodology, however, the goal should be to understand how the pandemic and existing institutional structures inhibit the success and progress of students of color, variations across disciplines, and particular interventions universities can employ to alleviate disproportionate impacts on STEM graduate students of color.

Early Career Pathways of STEM PhDs: The Impact of COVID-19

For more than a decade, graduate schools have expressed interest in collecting information on their graduates' career pathways. Although the number of research doctorate recipients has increased dramatically over the last several decades (i.e., 172 percent over three decades), a majority of STEM graduates (about 60 percent) work outside of academia. Only 25 percent are employed in tenure and tenure-track positions within universities. In recognition of the importance of the non-faculty career track, universities want to know more about the career outcomes of their graduates. Graduate deans recognize that this kind of information aids faculty as they review the curriculum to ensure their programs prepare students well for the jobs and careers they are likely to follow. National organizations like the Council of Graduate Schools and the American Association of Universities, as well as research institutes such as NORC, have conducted research designed to inform universities' capacities to collect this critical information. And although there is still no nationally agreed upon template for collecting career pathway information on graduates, several universities currently have data collection schemes.

Our RAPID survey did indicate that the impact on career pathways concerned many graduate deans and programs. However, discussion during our convening highlighted some marked differences in COVID impact based on discipline and field of study. Anecdotal information suggested a significant uptick in PhD placements in the biomedical sciences (especially outside of academia), with other fields falling dramatically behind.

Research illuminating the impact of the pandemic on graduation and early career placement of STEM PhDs is required to inform our national investment strategy in STEM fields, employers interested in hiring STEM graduates, and universities concerned with matching enrollment to demand. Enough universities currently have schemes to track this information that it would be possible to compare the graduating classes of 2019, 2020, and 2021 to ascertain the impact of COVID across five broad STEM fields.

The Benefits and Burdens of Moving Online: A Study of the Consequences of the Shift to Virtual Graduate Education in Response to COVID-19

Moving from face-to-face to virtual communication for conducting graduate education was one of the most universal adaptations reported in our survey of the top STEM graduate-producing universities in the United States. While only 18 percent of our respondents indicated that they were fully capable of going online in the pre-COVID era, 92 percent reported providing virtual instruction, either hybrid or fully online, by the time of our survey in summer 2020. This transformation impacted almost every aspect of the STEM graduate student experience, including orientation, courses, examinations, defenses, laboratory practice, fieldwork, professional development, mental and physical health support, and advising. Many deans surveyed in this RAPID study perceived this more extensive use of electronic technology as an innovation that should be sustained in post-COVID times. Simultaneously, many deans noted limitations coinciding with the shift; problems ranged from the differential access to electronic technology, unmet social-emotional needs, and the loss of informal education in the virtual environment.

Because this change has been universal, it is critical to study what has worked and what has not in each of those areas most significantly impacted. We need to investigate how the impact of the pandemic varied across disciplines and institutional type and whether the benefits or burdens accrued equally across racial and gender lines. As found in our study, it is also important to note that virtual is not an either-or situation. Many strategies combine communication media along a continuum, from face-to-face to hybrid to virtual. Future research needs to be sensitive to those variations as it investigates the expanded use of virtual technologies at every stage of the graduate student experience.

Conclusion

Traditionally, U.S. graduate schools have been regarded as the bastion of academic conservatism. COVID-19 turned them into a laboratory for innovation in U.S. higher education. To be sure, reform has long been a topic of debate and interest in American graduate schools, and many universities have made significant progress on that front. But the pandemic introduced an urgency for change and a risk-taking orientation that moved graduate schools nationwide to innovate in ways that to many would have seemed impossible in pre-pandemic times.

This study explored the impact of the COVID-19 pandemic by documenting our universities' responses as they strove to maintain academic progress, research progress, and the health and well-being of students, while simultaneously sustaining master's and doctoral programs. Yet, the most crucial contribution has been to illuminate the host of innovations that emerged in the process.

We hope these findings and insights will spur all of us—graduate education leaders and researchers alike—to reflect further on the pandemic's impact on and implications for graduate education in STEM fields. Reforming graduate education is recognized as both necessary and overdue, and the COVID-19 pandemic constraints have provided a critical impetus—and opportunity—to instigate, accelerate, and test a host of measures to advance meaningful reform.

APPENDICES

Appendix A:
Virtual Convening Agenda

Graduate Schools Respond to COVID-19: Promising Pathways to Innovation and Sustainability in STEM Education

TUESDAY, SEPTEMBER 29 | DAY 1

Time: 1-5pm ET

SESSION DESCRIPTION	LEAD / PANELISTS	TIME
Housekeeping/Overview of Technology	Istrico Productions	1:00-1:05pm
Welcome/Introduction to Workshop	Debra W. Stewart, NORC	1:15-1:20pm
Overview of Methodology	Ann Kearns Davoren, NORC	1:20-1:35pm
Session 1 **Crisis Management and Program Preservation: Things that Worked and Opportunities for Improvement from a Graduate School Perspective** This will focus on the over-all approach to managing the crisis and specific strategies for ensuring program preservation	Facilitator: Karen Grigorian, NORC Panelists: Jerome Kukor, Rutgers University - New Brunswick Cari Moorhead, University of New Hampshire Craig Ogilvie, Montana State University	1:35-1:45pm Facilitator remarks 1:45-2:15pm Panel of Deans 2:15-2:25pm Q&A
Session 2 **Academic and Research Continuity**	Facilitator: Erin Knepler, NORC Panelists: James Wimbush, Indiana University Bloomington Elizabeth Watkins, University of California San Francisco David Kieda, University of Utah	2:35-2:45pm Facilitator remarks 2:45-3:15pm Panel of Deans 3:15-3:25pm Q&A

SESSION DESCRIPTION	LEAD / PANELISTS	TIME
Virtual Convening Break	All	3:35-3:45pm
Session 3 **Student Health and Well-being**	Facilitator: Ann Kearns Davoren, NORC Panelists: James Grover, University of Texas at Arlington Barbara Knuth, Cornell University Dana Williams, Howard University	3:45-3:55pm Facilitator remarks 3:55-4:25pm Panel of Deans 4:25-4:35pm Q&A
Day 1 Wrap-up	Debra W. Stewart, NORC	4:35-5:00pm Sum up the day and introduce Day 2

WEDNESDAY, SEPTEMBER 30 | DAY 2

Time: 1-5pm ET

SESSION DESCRIPTION	LEAD / PANELISTS	TIME
Housekeeping/Overview of Technology	Istrico Productions	1:00-1:05pm
Welcome back and overview for the day	Debra W. Stewart, NORC	1:05-1:15pm
Session 4 **Technological Innovation**	Facilitator: James R. Neumeister, NORC Panellists Peter Harries, North Carolina State University at Raleigh Janet Rutledge, University of Maryland, Baltimore County William Graves, Iowa State University	1:15-1:25pm Facilitator remarks 1:25-1:55pm Panel of Deans 1:55-2:05pm Q&A

SESSION DESCRIPTION	LEAD / PANELISTS	TIME
Networking break	All	2:05 – 2:30pm Provide Zoom break-out rooms with assigned topics
Session 5 **Policy/Process Innovation**	Facilitator: James R. Neumeister, NORC Panelists: Wojtek Chodzko-Zajko, University of Illinois at Urbana-Champaign Clay Gloster, North Carolina A&T State University Claudia Tomany, Saint Cloud State University	2:30-2:40pm Facilitator remarks 2:40-3:10pm Panel of Deans 3:10-3:20pm Q&A
Virtual Convening Break	All	3:20-3:30pm
Session 6 **Sustaining Innovation**	Facilitator: Erin Knepler, NORC Panelists: Karen DePauw, Virginia Polytechnic Institute and State University Lisa Tedesco, Emory University Suzanne Barbour, University of North Carolina at Chapel Hill	3:30-3:40pm Facilitator remarks 3:40-4:10pm Panel of Deans 4:10-4:20pm Q&A
Day 2 Wrap-up	Debra W. Stewart, NORC	4:20-5:00pm Sum up the convening and next steps

Appendix B:
Key Questions to Inform the Convening Discussion

Six major topics will frame the discussion over the two-day convening. Under each topic, panelists and all convening participants are invited to comment on a series of questions from their own institutional experience.

The three topics discussed on the first day of the convening address how universities came to understand the challenges and strategies they adopted in response to the pandemic crisis. The second day will feature three topics focused directly on innovations in graduate education that emerged from the crisis. In addition to thinking about technological, policy, and practice innovations, it may also be helpful to think about how innovations can be classified in another way: (1) innovations that were primarily an acceleration of activity already underway, (2) innovations that were "new to us" though may have been in place at other institutions previously, or (3) entirely new innovations. All of these kinds of innovation are essential to share and understand. All three represent significant pathways to improving graduate education.

Session 1: Crisis Management and Program Preservation: Things that Worked and Opportunities for Improvement from a Graduate School Perspective

What can we learn from how our universities approached managing the COVID-19 crisis and how we shared specific strategies to ensure program preservation?

- What aspects of your university's response to the crisis were most important in ensuring graduate student progress and program stability?
- How might you consider urging your university to do things differently in the future?
- Will your university institutionalize a particular form of crisis management because of the pandemic experience?
- As enrolling students and ensuring good retention are critical to any graduate program's success, were there particular strategies for recruitment and retention that seemed promising or ones that should be avoided?

Session 2: Ensuring Academic Progress and Research Continuity for All Graduate Students

- What were/are the largest obstacles to overcome in assuring students make academic progress?
- Are there significant variations across STEM fields? Are there lessons learned in one field that could apply in another?
- Are there significant variations by degree level, master's versus PhD?
- What were/are the most significant obstacles to overcome in assuring students make research progress?
- Are there notable variations across STEM fields? Are there lessons to be learned from one field that could be applied in another?
- Concerning maintaining academic progress in assuring research continuity, what were/are the challenges unique to international students? Are there lessons learned that you would like to share?
- Concerning maintaining academic progress and assuring research continuity, what were/are challenges unique to students from underrepresented populations? Are there lessons learned that you would like to share?

Session 3: Sustaining the Health and Well-Being of All Graduate Students

- What were the greatest obstacles to overcome to ensure the health and well-being of graduate students on your campus?
- On your campus, were there particular challenges associated with ADA (disabilities) issues, insurance concerns, or access to medical treatment facilities?
- Concerning mental well-being, how did the pandemic exacerbate existing problems, what new problems emerged, and how did the existing mental health support system respond?
- What were the life management/family responsibility challenges that emerged, and how were graduate schools and/or universities able to respond?
- Concerning all the above, what was the impact of racial or gender disparities that may have existed pre-pandemic? Are there lessons learned and strategies to share?

Session 4: Technological Innovations: Search for the Silver Lining

- How has technology facilitated innovation across the graduate school and graduate programs in response to the crisis of COVID-19? Topics might include recruitment, admissions, teaching/coursework, advising, mentoring, laboratory research, field research, supporting student health and well-being, examinations, or other aspects of graduate education.

- In considering this question, remember that innovations may be an acceleration of activity already underway, or may be new to your institution though in place at other institutions. Some innovations may be entirely new. All types of innovation represent significant pathways to improving graduate education.

Session 5: Innovations in University or Graduate Policy and Process: Search for the Silver Lining

- What innovations in university policy or process have been adopted or are occurring at your institutions in response to the COVID-19 crisis? Topics might include recruitment and admissions; mentoring and advising; financing (assistantships, fellowships, other financial support); fundraising; or career /placement.

- In considering this question, remember that innovations in policy or process may be an acceleration of activity already underway, or may be new to your institution though in place at other institutions. Some innovations may be entirely new. All types of innovation represent significant pathways to improving graduate education.

Session 6: Requirement to Sustain Innovations

- It is now commonplace to say that universities, including graduate education, will be forever changed because of this pandemic. The question is: in what ways, toward what ends, and are the positive innovations sustainable?

- How will the innovations engendered in response to COVID-19 intersect with the political movement for racial equality and social justice?

- How will the innovations triggered as a response to COVID-19 fare given the financial constraints facing many universities going forward?

- What have we learned about new ways of leading and managing as universities leaders have responded to the challenges of COVID-19?

Appendix C: Survey Text

Informed Consent Page

Thank you for your participation in our NSF-funded survey, "Ensuring the Success and Sustainability of STEM Graduate Programs in Response to COVID-19." The purpose of the survey is to identify challenges the COVID-19 pandemic poses to graduate STEM programs at colleges and universities across the United States, as well as document and share innovative strategies that institutions employed during the crisis. Responses to the survey will help to inform a subsequent convening and final recommendations report, which will share promising practices that institutions used to adapt to the numerous ways COVID-19 impacted their STEM graduate programs, students, and research.

Your responses are voluntary and confidential. No individuals or their institutions will be identified in any reports. Please answer the survey questions as completely as possible. You may refuse to provide a response to any question you prefer not to answer or to any you feel do not apply to you. You may stop participating at any time. By entering the survey, you are granting consent to participate in this research.

We estimate that it will take you about 20 minutes to complete this survey.

If you have any questions or concerns, you may contact the research team at nsfcovid19survey@norc.org. You can also visit the following website for additional information: https://www.norc.org/Research/Projects/Pages/ensuring-the-success-of-stem-graduate-students-and-research-programs-during-the-COVID-19-crisis.aspx.

If you have any questions or concerns about your rights as a research participant, please contact the NORC IRB Manager by this toll-free phone number: (866) 309-0542.

Demographics

For purposes of this survey, "STEM" includes the traditional science, technology, engineering, and mathematics fields, as well as the social and behavioral sciences (e.g., economics, psychology, sociology).

1. **Regarding plans for fall 2020, please answer the following to the best of your current knowledge.**
   Answer "Yes" even if these statements apply to only a portion of your students, laboratories, or fieldwork sites and even if alternative arrangements are used in those settings; for example, implementing physical distancing requirements; restricting the number of individuals allowed in class sessions, labs, or field settings; or conducting activities using a hybrid/blended format that is partially online and partially in-person.

	No	Yes
Graduate students will be on campus for inclassroom instruction in the fall	○	○
STEM laboratories will be open in the fall for PIs and graduate students	○	○
STEM field work/research will be conducted in the fall for PIs and graduate students	○	○

2. **Were you a part of the central administration team/task force that developed the institutional response to COVID-19?**

   ○ No

   ○ No, but another senior graduate school official was a part of the team

   ○ Yes

   ○ Our institution did not have a central team/task force

3. **How helpful was your institution's crisis management plan in responding to the effects of COVID-19 on graduate programs?**

   - ○ Not at all helpful
   - ○ Somewhat helpful
   - ○ Very helpful
   - ○ N/A – Our institution did not have a crisis management plan

4. **Is your institution or graduate school using any of the following to address COVID-19 issues with graduate students and graduate programs?**

	No	Yes
Central website where updates are posted	○	○
Email blasts	○	○
Town hall meetings (can be virtual)	○	○
Designated COVID response team to field questions	○	○
Designated individual in the graduate school to field questions	○	○
Other, please specify: _____	○	○

ACADEMICS

Please consider all courses that are delivered in online, remote, or virtual formats (whether synchronous or asynchronous) as online. Courses that are conducted in-person but are simultaneously available to students via Zoom or similar technology are NOT considered online.

5. **After the immediate impacts of COVID-19 have passed, do you anticipate any of your STEM graduate programs will expand the following?**

	No	Yes	N/A – We don't currently offer this
Courses taught **entirely** online or in a remote format	○	○	○
Hybrid courses taught partially online and partially in-person	○	○	○
Degree **programs entirely** in an online or remote format	○	○	○
Hybrid degree **programs** offered partially online and partially in-person	○	○	○

6. **Prior to COVID-19**, approximately what percent of your STEM graduate courses were taught **entirely** online?

	None of these courses were online	Up to 25%	26-50%	51-75%	76-99%	100%
Master's Programs	○	○	○	○	○	○
PhD Programs	○	○	○	○	○	○

7. **After the immediate impacts of COVID-19 have passed**, approximately what percent of your STEM graduate courses do you anticipate will be taught **entirely** online?

	None	Up to 25%	26-50%	51-75%	76-99%	100%
Master's Programs	○	○	○	○	○	○
PhD Programs	○	○	○	○	○	○

8. **Prior to COVID-19**, how would you have rated your institution's technical capacity to provide online/distance learning for graduate students? When answering, please consider both your institution's internal abilities and any then-existing arrangements with third-party providers or online program management companies.

   - ○ Not capable of supporting online/distance learning
   - ○ Marginally capable
   - ○ Somewhat capable
   - ○ Largely capable
   - ○ Fully capable of supporting online/distance learning

9. As a result of COVID-19, did your institution **temporarily** use or expand a pass/fail type of grading system for graduate students instead of traditional letter or percent grades?

   - ○ No
   - ○ Yes, we provided the option but didn't require it
   - ○ Yes, we required it of all graduate students

10. Did the pass/fail criteria for graduate students differ from undergraduate students (e.g., a C in a graduate course is considered failing at most institutions, but passing for most undergraduate courses)?

    - ○ No
    - ○ Yes

Please consider all courses that are delivered in online, remote, or virtual formats (whether synchronous or asynchronous) as online. Courses that are conducted in-person but simultaneously available to students via Zoom or similar technology are NOT considered online.

11. **In response to COVID-19, has your institution provided or expanded use of the following?**

	No	Yes
Collaboration with other institutions to provide online courses for graduate students	○	○
Offering academic credit for graduate students completing MOOCs if certain criteria are met	○	○
Contractual agreements with third parties, such as Online Program Managers (OPMs), to develop or provide online courses or programs for graduate students	○	○
Collaboration with other institutions or groups to provide online professional development to graduate students	○	○
Other, please specify _____	○	○

12. **In response to COVID-19, what proportion of your in-person graduate courses moved to a remote/online format, either in whole or in part? (Please provide your best estimate.)**

13. **In response to COVID-19, were any of the following provided to assist with the transition to online classes?**

	No	Yes
Training or resources for students to effectively learn online	○	○
Training or resources for **TAs** to effectively teach online	○	○
Training or resources for **faculty** to effectively teach online	○	○
Accommodations for students with disabilities (e.g., captioning of lectures or videos)	○	○
Provided or expanded wifi "hot spots" around campus	○	○

14. **Regarding the transition to online classes, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.**

15. Did any of the following pose obstacles for your STEM graduate students in transitioning to online learning?

	No obstacle at all	A minor obstacle	A moderate obstacle	A major obstacle
Access to a reliable computer	○	○	○	○
Access to other reliable computer hardware (e.g., printers, scanners)	○	○	○	○
Access to software (e.g., statistical packages)	○	○	○	○
Access to reliable internet service	○	○	○	○
Access to library resources	○	○	○	○
Access to academic support services (e.g., statistics tutoring, writing lab)	○	○	○	○
Completion of required internships, practica, or other experiential learning activities	○	○	○	○
Other, please specify_____	○	○	○	○

16. In response to COVID-19, did your graduate programs make any of the following changes?

	No	Yes	We did this pre-COVID
Use remote proctoring for online course exams or quizzes	○	○	○
Allow online administration of qualifying exams	○	○	○
Allow online administration of thesis defenses	○	○	○
Allow online administration of doctoral exams (preliminary and final exams)	○	○	○
Allow online dissertation proposals	○	○	○
Allow online dissertation defenses	○	○	○
Changed established timelines for degree completion for master's students (extended timelines)	○	○	○
Changed established timelines for degree completion for PhD students (extended timelines)	○	○	○
Automatically extended funding for master's students	○	○	○
Automatically extended funding for PhD students	○	○	○
Other, please specify _____	○	○	○

17. Please rate your agreement with the following statements about online dissertation defenses:

	Strongly Disagree	Disagree	Agree	Strongly Agree
Online defenses produce greater participation from guests and the public	○	○	○	○
Conducting defenses online improves the civility level of the defense	○	○	○	○
Online defenses should be expanded	○	○	○	○

18. Please indicate your level of agreement with the following statement: In light of our COVID-19 experiences, our institution is considering ways to expand our use of **formative** evaluation of graduate student academic and research performance **(e.g., more real-time feedback and low stakes early assessments)**.

- ○ Disagree
- ○ Somewhat disagree
- ○ Somewhat agree
- ○ Agree

19. Regarding formative evaluations, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.

20. Please indicate your level of agreement with each of the following statements regarding advising/ mentoring during COVID-19:

	Disagree	Somewhat Disagree	Somewhat Agree	Agree
Graduate students received consistent advising and/or mentoring from graduate faculty	○	○	○	○
Virtual advising (e.g., Zoom) has been an adequate replacement for in-person contact	○	○	○	○

21. Regarding graduate academic policies and practices, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.

RESEARCH

22. Which statement **best** represents the status of your institution's STEM laboratories **during COVID-19**?

- ○ All the laboratories remained open and operated as usual
- ○ All the laboratories remained open but with physical distancing and other enhanced safety measures put in place
- ○ Some of the laboratories closed and some remained open (including any that may have remained open with physical distancing and other enhanced safety measures)
- ○ Only laboratories designated as doing essential work remained open
- ○ All laboratories closed when the campus closed
- ○ Other, please specify _____

23. a. What proportion of STEM research at your institution was delayed or discontinued **due to COVID-19**?

b. What proportion of STEM research at your institution do you anticipate will be delayed or discontinued in **Fall 2020**?

24. At your institution, how would you rate the overall impact of delayed or discontinued research on STEM **graduate student progress** within the following fields?

	No impact	Minor impact	Major impact	N/A – No programs in this area
Biological, agricultural, and environmental life sciences	○	○	○	○
Computer & information sciences	○	○	○	○
Engineering	○	○	○	○
Mathematics & statistics	○	○	○	○
Physical sciences, geosciences, atmospheric, and ocean sciences	○	○	○	○
Social, behavioral, & economic sciences	○	○	○	○

25. **During COVID-19**, to what extent was laboratory and field-based research able to use online, virtual, or distance formats to remain productive while labs or field sites were inaccessible?

- ○ Not at all
- ○ A small extent
- ○ A moderate extent
- ○ A great extent
- ○ N/A - All labs and field sites remained accessible during COVID-19

26. Were any STEM graduate students deemed "essential" at your institution for purposes of maintaining laboratory or field research activities (**excluding** teaching or instruction)?

- ○ No
- ○ Yes

27. Approximately, what percent of STEM graduate students were deemed "essential" for purposes of maintaining research or laboratory activities? (Please provide your best estimate.)

28. Did graduate students performing these essential activities receive hazard pay or extra compensation?

- ○ No
- ○ Some - Decisions were made on a departmental or case-by-case basis
- ○ Yes, all received extra compensation

29. Does your institution have any mechanism or process (e.g., website, hotline, or ombuds office) that allows graduate students to **confidentially or anonymously** report actions or directives that could endanger an individual's health or safety?

- ○ No
- ○ Yes, we had an established process prior to COVID-19
- ○ Yes, we implemented a process after the onset of COVID-19

30. When resuming lab/field activities, must any of the following requirements be met?

	No	Labs only	Field work only	Both labs & field work
Limiting the number of personnel in lab or field setting	○	○	○	○
Scheduling personnel to work on alternating dates/times	○	○	○	○
Use of personal protective equipment (PPE), such as masks, to prevent the spread of COVID-19	○	○	○	○
Other, please specify: _____	○	○	○	○

31. Has COVID-19 prompted a greater interest in taking steps to reduce the dependence of graduate students on individual PIs for their funding, research, or academic progress? Examples might include mentoring networks, committee-based advising, or central pool funding versus direct funding from PIs.

- ○ No
- ○ Yes

32. Regarding laboratory and field-based research, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.

Well-Being

33. Understanding that students will respond in different ways, what impact, overall, has COVID-19 had on the following aspects of your graduate students' well-being?

	No impact at all	Small impact	Moderate impact	Large impact
Access to housing (e.g., needing to leave campus housing, inability to pay rent)	○	○	○	○
Food insecurity	○	○	○	○
Physical health concerns	○	○	○	○
Feelings of loneliness/social isolation	○	○	○	○
Other mental health concerns	○	○	○	○
Other, please specify_____	○	○	○	○

34. Please indicate if your institution and/or graduate students themselves are coordinating any of the following to help maintain a sense of community during COVID-19. *Select all that apply for each.*

	No	Yes, institution coordinating	Yes, students coordinating
Increased frequency of general communications via special newsletters, email blasts, etc.	○	○	○
Hosting virtual coffee breaks, happy hours, or other social gatherings (e.g., book club)	○	○	○
Hosting virtual academic meetings (e.g., speaker series, research presentations)	○	○	○
Coordinating meetings about wellness topics (e.g., mental health, stress, exercise)	○	○	○
Coordinating support groups	○	○	○
Other, please specify _____	○	○	○

35. What impact, overall, has COVID-19 had on current **international** graduate students at your institution in each of the following areas?

	No impact at all	Small impact	Moderate impact	Large impact
Finances	○	○	○	○
Housing	○	○	○	○
Optional Practical Training (OPT)	○	○	○	○
Ability to return to home country	○	○	○	○
Ability to re-enter the United States after returning to home country	○	○	○	○
Other, please specify_____	○	○	○	○

36. Regarding support and assistance for **international** graduate students, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.

37. What impact, overall, has COVID-19 had on your institution's graduate students **with families** in each of the following areas?

	No impact at all	Small impact	Moderate impact	Large impact
Finances	○	○	○	○
Child care	○	○	○	○
Home schooling	○	○	○	○
Access to health care for family	○	○	○	○
Other, please specify____	○	○	○	○

38. What impact, overall, has COVID-19 had on graduate students **with disabilities** at your institution in each of the following areas?

	No impact at all	Small impact	Moderate impact	Large impact
Finances	○	○	○	○
Accessibility of online/distance courses	○	○	○	○
Accessibility of campus disability support services	○	○	○	○
Accessibility of community-based services	○	○	○	○
Other, please specify_____	○	○	○	○

39. **Prior to COVID-19**, did your institution provide **mental** health services that were accessible to the graduate students?

- ○ No
- ○ Yes

40. Has your institution continued to provide mental health services to graduate students during COVID-19? (These could be offered as in-person or as virtual/tele-counseling sessions.)

- ○ No, we suspended all mental health services
- ○ Yes, but we're offering services for students **in crisis only**
- ○ Yes, we're continuing to offer mental health services to all students in need

41. Regarding graduate student well-being, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.

FINANCE

42. As a result of COVID-19, do you anticipate your institution will cut the budget of the graduate school/ graduate programs?

- ○ No
- ○ Yes

43. How large do you anticipate budget cuts will be in the following aspects of graduate education?

	No change	Minor cuts	Major cuts
Student funding/assistantships	○	○	○
Recruitment of faculty	○	○	○
Recruitment of students	○	○	○
Faculty research	○	○	○
Student research	○	○	○
Diversity, equity, and inclusion efforts	○	○	○
Professional development for students	○	○	○
Other, please specify _____	○	○	○

44. As a result of COVID-19, what will be the impact in the following areas on graduate programs at your institution?

	Substantially smaller	Somewhat smaller	About the same	Somewhat larger	Substantially larger	Unknown or Under Discussion
The size of the **incoming** cohort of students (Fall 2020)	○	○	○	○	○	○
The size of **future** cohorts of students (Fall 2021+)	○	○	○	○	○	○
The **number** of financial packages for students	○	○	○	○	○	○
The **value** of financial packages for students	○	○	○	○	○	○
The number of courses available to graduate students	○	○	○	○	○	○
The number of research assistantships available to graduate students	○	○	○	○	○	○
The number of teaching assistantships available to graduate students	○	○	○	○	○	○
The number of professional development opportunities for graduate students	○	○	○	○	○	○

45. Is your institution providing any financial support to graduate students this summer?

- ○ No
- ○ Yes, summer support was already included in their packages
- ○ Yes, we provided new or additional support for the summer

46. Will **domestic** graduate students, who are unwilling or unable to be physically present on campus this fall, be able to continue an assistantship?

	No	Yes	Depends on the nature of the work	N/A – We don't offer this type of assistantship
Research assistantship	○	○	○	○
Graduate assistantship	○	○	○	○
Teaching assistantship	○	○	○	○

47. Will **international** graduate students **residing abroad**, who are unwilling or unable to be physically present on campus this fall, be able to continue an assistantship?

	No	Yes	Depends on the nature of the work	N/A – We don't offer this type of assistantship
Research assistantship	○	○	○	○
Graduate assistantship	○	○	○	○
Teaching assistantship	○	○	○	○

48. Will **international** graduate students **residing in the U.S.**, who are unwilling or unable to be physically present on campus this fall, be able to continue an assistantship?

	No	Yes	Depends on the nature of the work	N/A – We don't offer this type of assistantship
Research assistantship	○	○	○	○
Graduate assistantship	○	○	○	○
Teaching assistantship	○	○	○	○

49. In terms of addressing COVID-related financial impacts on graduate students, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.

CONTINUITY

50. In response to COVID-19, did you make any of the following changes to your admissions requirements or criteria? Please answer "Yes" only if the change applied to all students and not granted as an exception or on a case-by-case basis.

	No	Yes	In place prior to COVID-19	N/A – Not a part of our criteria
Extended applications deadline	○	○	○	○
Waived standardized test requirement (e.g., GRE)	○	○	○	○
Waived English proficiency exam	○	○	○	○
Expanded consideration of pass/fail or credit/no credit courses in evaluating transcripts	○	○	○	○
Expanded holistic review of applicants	○	○	○	○
Waived campus visits/interviews	○	○	○	○
Conducted virtual interviews	○	○	○	○
Other, please specify _____	○	○	○	○

51. What do you foresee will be the effect of <u>COVID-related changes in your admissions processes</u> on your incoming STEM graduate cohorts in the following areas?

	Negative effect	No effect	Positive effect
Racial/ethnic diversity of incoming students	○	○	○
Gender diversity of incoming students	○	○	○
Socioeconomic diversity of incoming students	○	○	○
Overall strength of incoming students	○	○	○

52. Compared to before COVID, how would you characterize your institution's overall efforts to ensure that newly admitted graduate students enroll for the fall 2020 term?

- ○ Substantially less effort
- ○ Somewhat less effort
- ○ No change
- ○ Somewhat more effort
- ○ Substantially more effort

53. For each of the following time periods, please identify how orientation of new graduate students at your institution was (or will be) conducted.

	Completely online	Completely in-person	Mixture of online and in-person	Varies by department or program
Before COVID	○	○	○	○
This fall	○	○	○	○
After COVID has passed	○	○	○	○

54. Compared to prior years, how much of a change in **retention** do you anticipate **in fall 2020** for…

	Large decrease	Moderate decrease	No Change	Moderate increase	Large increase
Domestic students?	○	○	○	○	○
International students?	○	○	○	○	○

55. Regarding recruitment and retention of **international** graduate students, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.

56. Regarding recruitment and retention of **domestic** graduate students, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.

57. As a result of COVID-19, how many graduate students at your institution:

	None or virtually none	A few	Some	Many	I don't know
Chose to delay their program completion	○	○	○	○	○
Were **forced** to delay their program completion	○	○	○	○	○
Had an internship, practicum, or other **experiential learning** activity cancelled or withdrawn	○	○	○	○	○

58. Overall, what do you anticipate the impact of COVID-19 will be on **job** placements for graduating students?

	Significantly fewer placements	Slightly fewer placements	No impact	Slightly more placements	Significantly more placements
Masters students	○	○	○	○	○
PhD students in positions within academia	○	○	○	○	○
PhD students in positions outside of academia	○	○	○	○	○

59. With regard to job placements, have certain STEM fields been negatively impacted more than others for **master's** graduates?

- ○ No
- ○ Yes, please specify the fields most affected _____

60. With regard to job placements, have certain STEM fields been more negatively impacted than others for **PhD** graduates?

- ○ No
- ○ Yes, please specify the field most affected_____

61. Regarding the overall health and sustainability of your STEM graduate programs moving forward, are there new or innovative approaches that were used during the COVID-19 crisis that you may continue or institutionalize in the future? If so, please briefly identify them here.

62. **What do you believe your top three challenges will be in the 2020-21 academic year?**
Please enter 1 for the greatest challenge, 2 for the second greatest, and 3 for the third greatest. Please only identify your top three.

	Rank
Providing more online education	
Maintaining academic progress of current students	
Assisting international students specifically	
Opening labs with necessary safety and precaution measures	
Resuming field work	
Student well-being issues	
Retaining of current students	
Recruiting of new students	
Other, please specify _____	

63. **Looking ahead to the 2021-22 academic year and beyond, what impact will COVID-19 have on STEM graduate programs at your university overall?**

- ○ Extremely negative
- ○ Negative
- ○ Somewhat negative
- ○ No impact
- ○ Somewhat positive
- ○ Positive
- ○ Extremely positive

64. **Please explain why you believe COVID-19 will ultimately impact your graduate programs overall.**

65. **If there is any other information you would like to provide pertaining to the topics covered in this survey, please use the space below.**

Thank you for your participation in our survey! If you have any questions or concerns, you may contact the research team at nsfcovid19survey@norc.org. You can also visit the following website for additional information: https://www.norc.org/Research/Projects/Pages/ensuring-the-success-of-stem-graduate-students-and-research programs-during-the-COVID-19-crisis.aspx.

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