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Disparities in Remote Learning Faced by First-Generation and Underrepresented Minority Students during COVID-19: Insights and Opportunities from a Remote Research Experience

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The COVID-19 pandemic forced an unprecedented shift to remote instruction across higher education, reducing access to critically important undergraduate research experience and potentially magnifying inequities faced by first-generation and underrepresented minority (URM) students in higher education. Through a novel course-based undergraduate research experience (CURE) at UCLA, delivered completely online, results of a unique, student-generated survey showed that the transition to remote learning was challenging for all students, increasing student workload, decreasing ability to focus on school, and limiting their ability to succeed. However, results showed significant disparities in remote learning that disproportionately impacted URM and first-generation students. These students had significantly greater expectations to help siblings with remote learning,; URM and first-generation students also suffered greater economic and food insecurity related to COVID-19. At the same time, this study demonstrates how student voices in survey development provide novel and actionable insights. While access to CUREs is often limited by laboratory space, by focusing on the research process, rather than specific laboratory skills, this study provides a scalable pedagogical model for remote undergraduate research experiences. Importantly, this model fostered student engagement and increased interest in further undergraduate research, including topics not directly related to the subject of this study, suggesting that online CUREs can be effective and impactful.

INTRODUCTION

Participation in undergraduate research is associated with increased persistence in science, technology, engineering, and math (STEM) degrees (1, 2) and increased ambition for pursuing graduate school (3–5). These benefits are particularly pronounced in students from underrepresented minority backgrounds (URM; defined by the National Science Foundation as Black, Hispanic, Native American, Alaska Native, or Pacific Islander) who typically have lower persistence and graduation rates in college than do White or Asian students (6), especially in STEM majors (7–9). Traditionally, undergraduate research is "apprenticed-based," with students doing mentored research in individual faculty labs, a model that greatly limits participation in undergraduate research. As such, even at major research institutions like the University of California, Los Angeles (UCLA), only about half of STEM majors ever engage in some form of undergraduate research (10).

Course-based undergraduate research experiences (CUREs) integrate authentic research experiences directly into the undergraduate curriculum, providing more students with access to research experiences than traditional apprentice-based research experiences (11, 12). Like apprentice-based research, CUREs improve graduation and STEM degree completion rates (13) and have a significant impact on the persistence of URM STEM students (13, 14). As such, CUREs have been proposed as a means of making STEM education more inclusive (9, 15).

While there are examples of CUREs that reach large numbers of students (16, 17), the majority of CUREs focus on smaller upper-division courses, limiting their reach and

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benefits. One reason for the inability to support larger numbers of students in CUREs is the restricted availability of laboratory space to support data collection using common laboratory protocols employed in molecular biology (18, 19), chemistry (20, 21), and other disciplines where technical expertise is the foundation of data collection. This limitation highlights the need for alternative approaches where more students can participate in CUREs without adding physical laboratory space.

The UCLA-HHMI Health Disparities and the Environment Program is a year-long program for sophomore prehealth students at UCLA focused on increasing diversity in medicine, public health, and research careers that promote health equity. The capstone of this program is a lab-based CURE where students use genetics and analytical chemistry to examine potential health risks of food insecure populations engaging in subsistence fishing in the polluted waters around Los Angeles. However, mandatory stay-at-home orders associated with the COVID-19 pandemic precluded any in-person, hands-on instruction at UCLA in Spring 2020 when this CURE was scheduled. As such, the course was reenvisioned for a remote learning environment employing a student-centered approach.

As a class, we developed a novel, student-driven research project focused on the experience of UCLA students with remote learning. Given that this year-long program focuses on health disparities, particularly with respect to URM and low-socioeconomic status communities, and given that students were unexpectedly plunged into learning remotely, they decided to explore disparities in remote learning environments. Of particular interest was how the experience of URM and first-generation college students may differ from students who do not share these identities. Additionally, because the students in this program were all STEM majors, they were also interested in how experiences with remote learning might differ for STEM and non-STEM majors.

URM and first-generation students face well-documented challenges in higher education. For example, on average, URM students have lower college degree completion rates (6), particularly in STEM majors (7–9). Drivers of this pattern include insufficient high school preparation (22, 23), struggles transitioning to college (24, 25), and unwelcoming STEM cultures (26). Similarly, first-generation students leave higher education at higher rates (27) and struggle in STEM majors (28, 29), reducing STEM persistence (30). First-generation college students comprise ~30% of all college students (31) and disproportionately come from URM and/or low-income backgrounds (32, 33), suggesting potentially important intersectionalities of individuals with these identities.

Given the above, there is concern that these challenges faced by URM and first-generation students could be exacerbated during COVID-19, when students are learning at home, in households where parents lack the educational experience to help their children and may not understand the time demands of being a STEM student. Early studies on remote learning during COVID-19 highlighted reduced motivation and desire to learn as major obstacles (34–36). Of particular concern is that students from lower socioeconomic backgrounds experienced more obstacles transitioning to online learning, especially in terms of accessing adequate study space, learning support, and scheduling conflicts (36). At UCLA, low-socioeconomic status students are disproportionately URM and first-generation students, suggesting that challenges related to COVID-19 may amplify existing challenges for these student demographics.

This study has two primary aims. First, we use student survey data to test whether URM and first-generation STEM students at UCLA experienced disparities in remote learning necessitated by the COVID-19 crisis. This survey focuses on three themes: (i) student experience with remote learning, (ii) students challenges during remote learning, and (iii) economic related challenges. This survey is unique in that it was fully developed by students enrolled in a CURE that transitioned to a fully online environment. The second aim of this study was to understand the experience of the students in this CURE, delivered completely online, and how this experience may inform the development of pedagogies for online CUREs, increasing access to authentic research experiences and the benefits they confer.

METHODS

Survey Development

We started survey development with each of the 20 enrolled students independently drafting five questions to explore the student experience with COVID-related remote learning. Given that our program spent the previous 6 months exploring health disparities associated with URM and low socioeconomic status populations, students decided to focus on how the student experience with remote learning might be different for URM and first-generation students, who tend to be from lower socioeconomic status, compared to students with other identities. Students focused on capturing experiences "before and after" the pandemic. For example, instead of asking "Is it hard to balance schoolwork with your household responsibilities?" we asked "Is it harder for you to balance schoolwork with your household responsibilities now than before COVID-19?"

As a class we categorized all individual questions by general topic, including education, health (physical and mental), and work (employment and housework). Students then worked in Zoom breakout rooms of four students each to select five questions that best captured critical aspects of the student experience during the COVID-19 pandemic and the transition to remote learning. Students prioritized questions that focused on (i) the student experience with online learning, (ii) balancing home and school responsibilities, and (iii) how COVID-19 impacted individual and family financial stress. They informed their choices of the most important questions by drawing on their own personal experiences as first-generation and URM students and the experiences of their peers. The lists from each breakout room were combined by the teaching assistants, and then, through class discussion, individual questions were reviewed, with those viewed as either too specific or redundant being subsequently removed.

At the next class meeting, the class, teaching assistants, and course instructors met with UCLA Professor Sylvia Hurtado to eliminate biased or leading questions, and to refine the questions and how they were asked. Through this process, we further refined the wording of survey questions, removing questions that could deter student response (e.g., immigration status) and developing additional questions to more completely explore particular topics. Lastly, because of sensitivities to survey fatigue, students voted on the final list of questions to create the shortest survey that they felt captured the most important aspects of the student experience with COVID-19 remote learning. We then finalized these questions with the director and researchers in the UCLA Center for Educational Assessment, who created the formal survey instrument in Survey Monkey, and added questions about student demographics. Most questions were scored from strongly disagree (1) to strongly agree (4), although some questions used yes (1) no (2), or decrease (1), no change (2), increase (3).

Sampling

We surveyed undergraduate students at the UCLA, a diverse institution with >31,000 undergraduates. In total, 26% of UCLA students are URM; 3% African American, <1% American Indian/Alaska Native, <1% Pacific Islander, and 22% Hispanic. The remainder is 27% White, 28% Asian, and 12% international. To maximize sampling of first-generation and URM students, we surveyed students in the Academic Advancement Program (AAP), an academic support program serving >5,600 UCLA undergraduates across all undergraduate majors. Approximately 80% of AAP students are first-generation college students and ~69% are URM. To maximize sampling of first-generation and URM STEM students, we surveyed ~800 students (current and alumni) in the Program for Excellence in Education and Research in the Sciences (PEERS), a 2-year, cohort-based, academic support program focused exclusively on STEM majors (except engineering) from underrepresented and underserved backgrounds (37). Since 2015, PEERS cohorts (~200 students each) have ranged from 52% to 75% first-generation and 84% to 95% URM. Lastly, we surveyed a randomized 20% (~6,300) of all UCLA undergraduates to capture students who are neither first-generation or URM. Because all PEERS students are also in AAP and because PEERS and AAP students could be randomly selected from the UCLA student body, students were alerted to the possibility of receiving this survey through AAP, PEERS, or the UCLA administration and were instructed to take the survey only once. We initially sent the survey in mid-May, during week 6 of a 10-week quarter, and then sent a reminder after the completion of finals in mid-June.

Analyses

We combined raw student response data and analyzed three comparison groups: (i) STEM vs. non-STEM, (ii) first-generation vs. "continuing" (e.g., not first-generation), and (iii) URM vs. non-URM. For each group, we calculated means and standard errors (SEs). Prior to statistical analyses, we tested for normality using a Kolmogorov-Smirnov test. Given that no distributions met the assumption of normality, we tested for significant differences in response distributions using the Mann-Whitney nonparametric test (38), with a $p < 0.05$ cutoff for statistical significance.

Next, we explored intersectionalities in the experience of STEM, URM, and first-generation students as follows. For each of these three aforementioned categories, we ran four separate analyses, disaggregating the data to make specific comparisons targeting the remote learning experience for students with multiple identities. For example, we divided all responses into STEM and non-STEM majors. Within STEM majors, we then compared responses for URM and non-URM students and then first-generation and non–first-generation students; we then repeated this approach for non-STEM majors. As above, we calculated means and SEs and tested for normality, ultimately using a Mann-Whitney nonparametric test with a $p < 0.05$ cutoff for statistical significance. Due to sample size limitations, we only examined intersections of two identities, not all three.

Student focus group

To understand the experience of the students enrolled in this remote CURE, upon completion of the course and after we had engaged in some preliminary analysis, researchers from the UCLA Center for Educational Assessment met with students to discuss their experience. In particular, our goal was to understand whether and how the project served as a CURE from the students' perspective. Ten students and one researcher, all of whom are reflected as coauthors of this study, met via Zoom for roughly 60 minutes. During this time, students were asked about (i) their expectations going into the quarter remotely, (ii) their motivation for pursuing Life Sciences, (iii) their level of satisfaction with the course, and (iv) what they perceived to be their greatest achievements or outcomes related to the course.

RESULTS

We initially sent the survey to UCLA students between May 5 and May 12, 2020. Given the overlap between PEERS, AAP, and the UCLA student body, we estimate that the survey was received by approximately 10,000 unique students. In total, 947 students responded. The ~9.5% response rate is relatively low, which suggests survey fatigue. However, this response rate was similar to other COVID-19 surveys conducted by UCLA and the University of California (e.g., https://www.csac.ca.gov/survey2020), meeting stringent conditions for course evaluation studies. In addition, not all respondents answered all questions, resulting in minor fluctuations in total sample size. Of the respondents, 60.1% were STEM vs. 39.9% non-STEM majors and 38.6% were first-generation vs. 61.4% non–first-generation. In total, 43.4% were URM, comprising 1.7% American Indian/Alaska Native, 6.9% African-American, and 36.0% Latino/a/x. The remainder were White/Caucasian (27%), Asian (33.7%), or "Other" (11.0%).

Common student experiences

On average, STEM (n = 313), first-generation (n = 302), and URM (n = 423) students all found the transition to remote learning significantly more challenging [see Table 1 (STEM vs. non-STEM), Table 2 (first-generation vs. continuing), and Table 3 (URM vs. non-URM)]. Similarly, all three groups experienced significantly greater technological challenges to participation in remote instruction (Fig. 1b). All students felt that remote instruction reduced their ability to succeed and were relatively neutral with respect to interest in further remote instruction, although there were no significant differences among comparison groups (Tables 1, 2, and 3).

STEM student experience

Analyses showed minimal differences between STEM (n = 313) and non-STEM students (n = 477) with remote learning (Table 1). STEM students were the least satisfied with remote instruction, experienced a significant increase in school workload, and indicated that their living situation reduced their ability to participate in remote instruction compared to non-STEM students. However, families of STEM students were more likely than families of non-STEM students to have the financial resources to last 2 to 3 months of stay-at-home orders and were more likely to have health insurance than non-STEM students. STEM students also reported a significant increase in food quality during stay-at-home orders. No other significant differences between STEM and non-STEM students were observed.

First-generation student experience

Analyses revealed substantial differences between the experience of first-generation (n = 302) and continuing students (n = 479) with remote learning (Table 2). First-generation students felt that the transition to remote learning increased their academic workload, while the pandemic also increased their work hours. Student living situation significantly reduced the ability of first-generation students to participate in remote instruction, and first-generation students also reported less time to focus on their schoolwork and had higher expectations to help siblings with remote learning. As a result, they found it more challenging to balance schoolwork with other household responsibilities.

Families of first-generation students were less likely to be financially secure prior to the COVID-19 pandemic, were less likely to have financial resources to cover 2 to 3 months of stay-at-home orders, and were less likely to have health insurance. These differences in financial security translated to differences in food security, with first-generation students having better access to quality food when on campus, prior to campus closure, and reporting reduced food quantity and quality as a result of COVID-19 stay at home orders (Table 2).

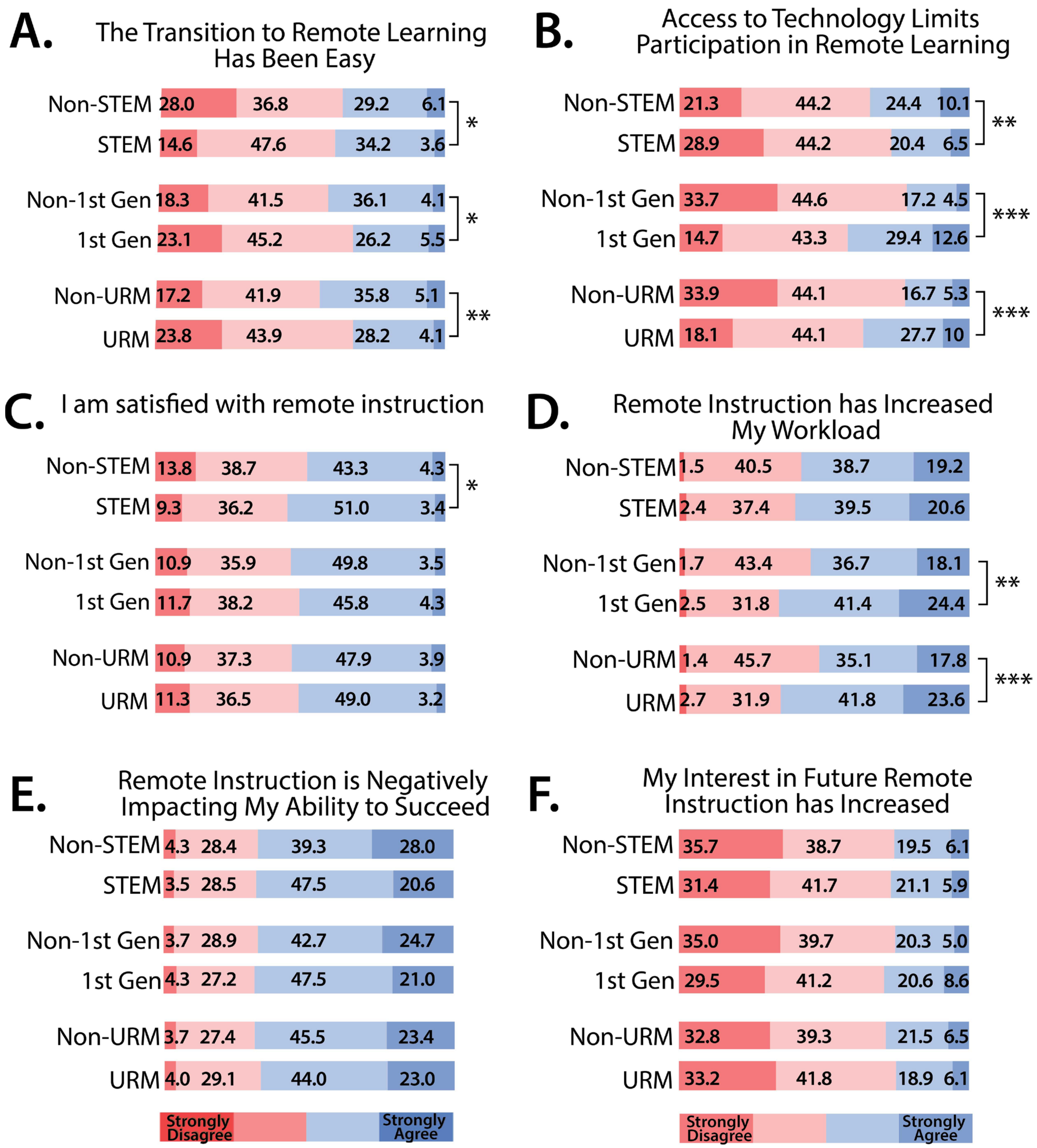
URM student experience

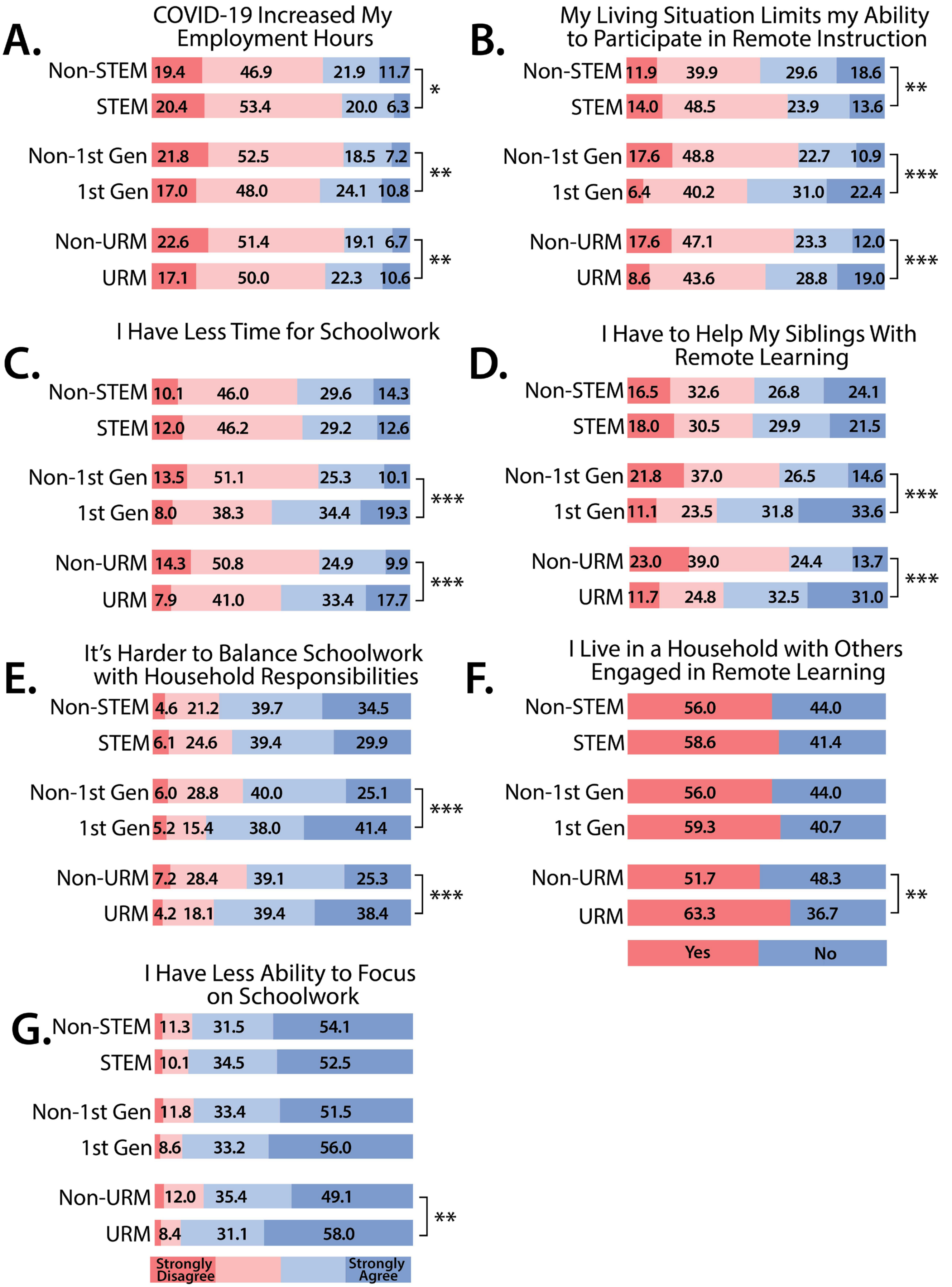
Like first-generation students, the experience of URM (n = 423) and non-URM students (n = 483) with remote learning varied greatly (Table 3). URM students felt that the transition to remote learning increased their academic workload and also reported significantly more work hours. URM students reported that their living situation reduced their ability to participate in remote instruction and that they had less time to focus on their schoolwork. URM students were more likely to be living with other students engaged in remote learning, had higher expectations to help siblings with remote learning, and found it more challenging to balance schoolwork with other household responsibilities. As a result, URM students were significantly less able to focus on their studies.

Families of URM students were less likely to be financially secure prior to the COVID-19 pandemic, were less likely to have the financial resources to weather 2 to 3 months of stay-at-home orders, and were less likely to have health insurance. Financial insecurity led to significant differences in food security, with URM students reporting reduced food quantity during the stay-at-home orders (Table 3).

STEM intersectionalities

Analyses of intersectionalities revealed a consistent pattern where URM and first-generation students experience significant disparities in remote learning. Examining only STEM majors, URM students (n = 238) had significantly worse outcomes across 14 of the 19 (73.7%) survey questions than non-URM students (n = 247) (Table 4). URM and non-URM STEM students were only similar in (i) their satisfaction with remote learning, (ii) their belief that remote learning is limiting their ability to succeed, (iii) students working more hours, (iv) changes in food quantity, and (v) changes in food quality. Similar to STEM majors, responses


A.
The Transition to Remote Learning Has Been Easy
Non-STEM 28.0 36.8 29.2 6.1
STEM 14.6 47.6 34.2 3.6
*
Non-1st Gen 18.3 41.5 36.1 4.1
1st Gen 23.1 45.2 26.2 5.5
*
Non-URM 17.2 41.9 35.8 5.1
URM 23.8 43.9 28.2 4.1
**
B.
Access to Technology Limits Participation in Remote Learning
Non-STEM 21.3 44.2 24.4 10.1
STEM 28.9 44.2 20.4 6.5
**
Non-1st Gen 33.7 44.6 17.2 4.5
1st Gen 14.7 43.3 29.4 12.6
***
Non-URM 33.9 44.1 16.7 5.3
URM 18.1 44.1 27.7 10
***
C.
I am satisfied with remote instruction
Non-STEM 13.8 38.7 43.3 4.3
STEM 9.3 36.2 51.0 3.4
*
Non-1st Gen 10.9 35.9 49.8 3.5
1st Gen 11.7 38.2 45.8 4.3
Non-URM 10.9 37.3 47.9 3.9
URM 11.3 36.5 49.0 3.2
D.
Remote Instruction has Increased My Workload
Non-STEM 1.5 40.5 38.7 19.2
STEM 2.4 37.4 39.5 20.6
Non-1st Gen 1.7 43.4 36.7 18.1
1st Gen 2.5 31.8 41.4 24.4
**
Non-URM 1.4 45.7 35.1 17.8
URM 2.7 31.9 41.8 23.6
***
E.
Remote Instruction is Negatively Impacting My Ability to Succeed
Non-STEM 4.3 28.4 39.3 28.0
STEM 3.5 28.5 47.5 20.6
Non-1st Gen 3.7 28.9 42.7 24.7
1st Gen 4.3 27.2 47.5 21.0
Non-URM 3.7 27.4 45.5 23.4
URM 4.0 29.1 44.0 23.0
Strongly Disagree
Strongly Agree
F.
My Interest in Future Remote Instruction has Increased
Non-STEM 35.7 38.7 19.5 6.1
STEM 31.4 41.7 21.1 5.9
Non-1st Gen 35.0 39.7 20.3 5.0
1st Gen 29.5 41.2 20.6 8.6
Non-URM 32.8 39.3 21.5 6.5
URM 33.2 41.8 18.9 6.1
Strongly Disagree
Strongly Agree


A.
COVID-19 Increased My Employment Hours
Non-STEM 19.4 46.9 21.9 11.7
STEM 20.4 53.4 20.0 6.3
*
Non-1st Gen 21.8 52.5 18.5 7.2
1st Gen 17.0 48.0 24.1 10.8
**
Non-URM 22.6 51.4 19.1 6.7
URM 17.1 50.0 22.3 10.6
**
B.
My Living Situation Limits my Ability to Participate in Remote Instruction
Non-STEM 11.9 39.9 29.6 18.6
STEM 14.0 48.5 23.9 13.6
**
Non-1st Gen 17.6 48.8 22.7 10.9
1st Gen 6.4 40.2 31.0 22.4
***
Non-URM 17.6 47.1 23.3 12.0
URM 8.6 43.6 28.8 19.0
***
C.
I Have Less Time for Schoolwork
Non-STEM 10.1 46.0 29.6 14.3
STEM 12.0 46.2 29.2 12.6
Non-1st Gen 13.5 51.1 25.3 10.1
1st Gen 8.0 38.3 34.4 19.3
***
Non-URM 14.3 50.8 24.9 9.9
URM 7.9 41.0 33.4 17.7
***
D.
I Have to Help My Siblings With Remote Learning
Non-STEM 16.5 32.6 26.8 24.1
STEM 18.0 30.5 29.9 21.5
Non-1st Gen 21.8 37.0 26.5 14.6
1st Gen 11.1 23.5 31.8 33.6
***
Non-URM 23.0 39.0 24.4 13.7
URM 11.7 24.8 32.5 31.0
***
E.
It's Harder to Balance Schoolwork with Household Responsibilities
Non-STEM 4.6 21.2 39.7 34.5
STEM 6.1 24.6 39.4 29.9
Non-1st Gen 6.0 28.8 40.0 25.1
1st Gen 5.2 15.4 38.0 41.4
***
Non-URM 7.2 28.4 39.1 25.3
URM 4.2 18.1 39.4 38.4
***
F.
I Live in a Household with Others Engaged in Remote Learning
Non-STEM 56.0 44.0
STEM 58.6 41.4
Non-1st Gen 56.0 44.0
1st Gen 59.3 40.7
Non-URM 51.7 48.3
URM 63.3 36.7
**
Yes No
G.
I Have Less Ability to Focus on Schoolwork
Non-STEM 11.3 31.5 54.1
STEM 10.1 34.5 52.5
Non-1st Gen 11.8 33.4 51.5
1st Gen 8.6 33.2 56.0
Non-URM 12.0 35.4 49.1
URM 8.4 31.1 58.0
**
Strongly Disagree
Strongly Agree

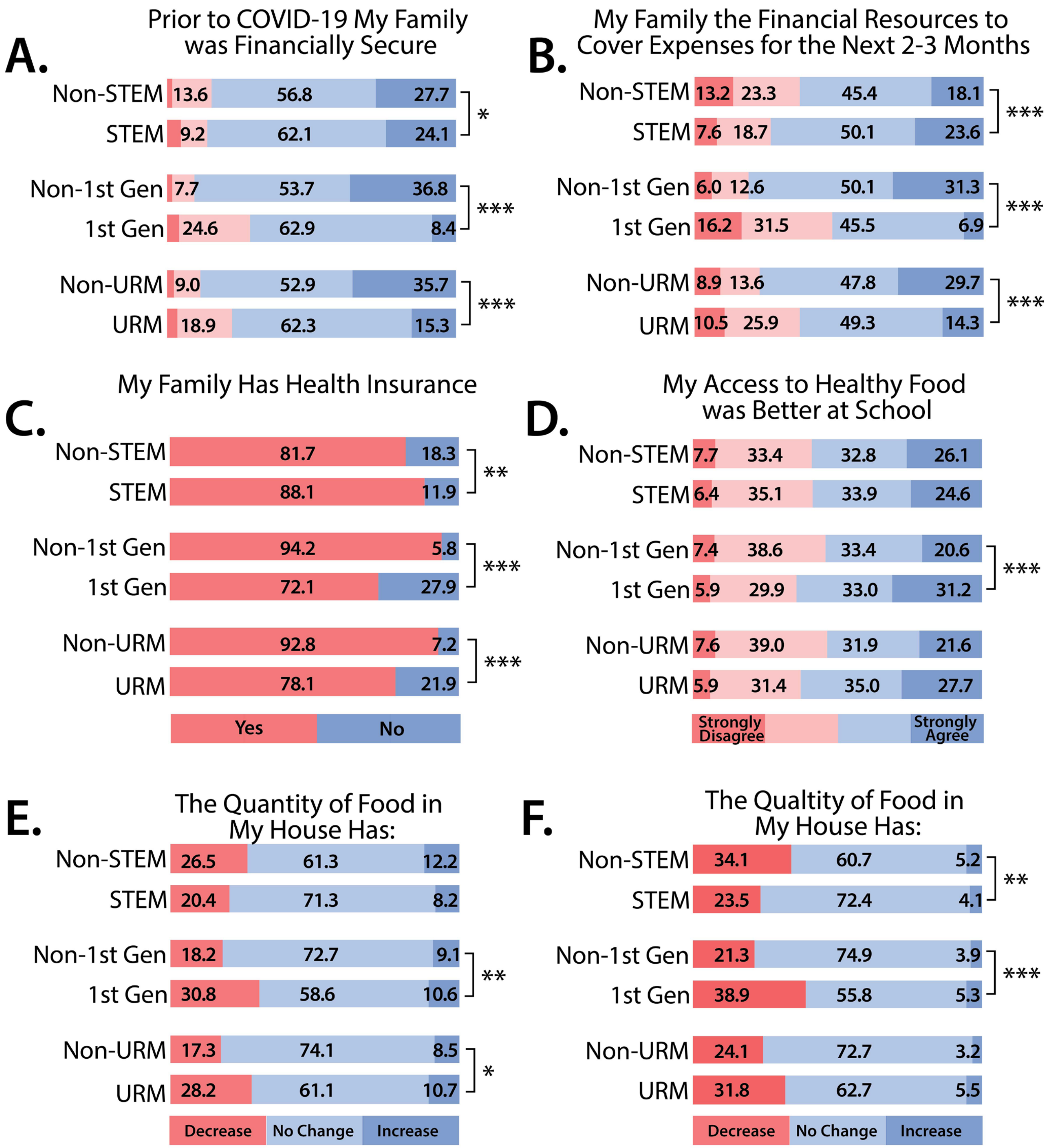

A.
Prior to COVID-19 My Family was Financially Secure
Non-STEM 13.6 56.8 27.7
STEM 9.2 62.1 24.1
*
Non-1st Gen 7.7 53.7 36.8
1st Gen 24.6 62.9 8.4
***
Non-URM 9.0 52.9 35.7
URM 18.9 62.3 15.3
***
B.
My Family the Financial Resources to Cover Expenses for the Next 2-3 Months
Non-STEM 13.2 23.3 45.4 18.1
STEM 7.6 18.7 50.1 23.6
***
Non-1st Gen 6.0 12.6 50.1 31.3
1st Gen 16.2 31.5 45.5 6.9
***
Non-URM 8.9 13.6 47.8 29.7
URM 10.5 25.9 49.3 14.3
***
C.
My Family Has Health Insurance
Non-STEM 81.7 18.3
STEM 88.1 11.9
**
Non-1st Gen 94.2 5.8
1st Gen 72.1 27.9
***
Non-URM 92.8 7.2
URM 78.1 21.9
***
Yes No
D.
My Access to Healthy Food was Better at School
Non-STEM 7.7 33.4 32.8 26.1
STEM 6.4 35.1 33.9 24.6
Non-1st Gen 7.4 38.6 33.4 20.6
1st Gen 5.9 29.9 33.0 31.2
***
Non-URM 7.6 39.0 31.9 21.6
URM 5.9 31.4 35.0 27.7
Strongly Disagree
Strongly Agree
E.
The Quantity of Food in My House Has:
Non-STEM 26.5 61.3 12.2
STEM 20.4 71.3 8.2
Non-1st Gen 18.2 72.7 9.1
1st Gen 30.8 58.6 10.6
**
Non-URM 17.3 74.1 8.5
URM 28.2 61.1 10.7
*
Decrease No Change Increase
F.
The Qualtity of Food in My House Has:
Non-STEM 34.1 60.7 5.2
STEM 23.5 72.4 4.1
**
Non-1st Gen 21.3 74.9 3.9
1st Gen 38.9 55.8 5.3
***
Non-URM 24.1 72.7 3.2
URM 31.8 62.7 5.5
Decrease No Change Increase

TABLE 1.
Comparison of STEM and non-STEM students in response to survey questions focused on experience with remote learning (1–6), balancing home and school responsibilities (7–13), and financial challenges (14–19).

Survey Question	non-STEM (*N* = 477)			
	que	mean ± SE	Z-score	*p* value
1. My transition to remote learning was easy	**2.16 ± 0.051**	**2.26 ± 0.034**	**-2.472**	**0.013**
2. I am satisfied with remote instruction	**2.40 ± 0.044[a]**	**2.48 ± 0.033[a]**	**-2.017[a]**	**0.044[a]**
3. Remote instruction increased my workload	2.73 ± 0.044	2.78 ± 0.036	-0.570	0.569
4. Remote instruction reduces my ability to succeed	2.91 ± 0.048	2.85 ± 0.036	-1.124	0.261
5. Access to technology reduces my ability to participate in remote instruction	**2.24 ± 0.051[a]**	**2.05 ± 0.040[a]**	**-2.943[a]**	**0.003[a]**
6. Remote instruction during COVID increased my interest in taking more remote classes	1.96 ± 0.050	2.01 ± 0.040	-1.006	0.315
7. I work more (e.g., employment) now than before COVID-19.	**2.26 ± 0.051[a]**	**2.12 ± 0.37[a]**	**-1.967[a]**	**0.049[a]**
8. I have less time to devote to my schoolwork	2.50 ± 0.048	2.43 ± 0.039	-0.895	0.371
9. I have less ability to focus on my schoolwork	3.35 ± 0.046	3.38 ± 0.035	-0.199	0.843
10. I live with other students engaged in remote learning (Yes=1, No=2)	1.41 ± 0.022	1.44 ± 0.027	-0.753	0.451
11. I help my siblings or other members of my household with remote learning	2.58 ± 0.058	2.55 ± 0.047	-0.445	0.656
12. It is harder for me to balance schoolwork with my household responsibilities	3.04 ± 0.049	2.94 ± 0.041	-1.725	0.085
13. My living situation limits my ability to participate in remote instruction	**2.57 ± 0.052[a]**	**2.39 ± 0.041[a]**	**-2.816[a]**	**0.005[a]**
14. Prior to COVID-19 my family was financially secure	3.10 ± 0.031	3.00 ± 0.041	-1.874	0.061
15. My household has financial resources to cover expenses for the next 2-3 months	**2.90 ± 0.038**	**2.68 ± 0.051**	**-3.262**	**0.001**
16. My family has health insurance (Yes=1, No=2)	**1.12 ± 0.015**	**1.18 ± 0.021**	**-2.581**	**0.010**
17. My access to quality food was better at school	2.77 ± 0.041	2.77 ± 0.051	-0.162	0.871
18. How COVID-19 impacted food availability in your household (Decrease=1, No Change=2, Increase=3)	1.88 ± 0.024	1.86 ± 0.033	-0.723	0.470
19. How COVID-19 impacted food quality in your household (Decrease=1, No Change=2, Increase=3)	**1.81 ± 0.022**	**1.71 ± 0.031**	**-2.781**	**0.005**

Except where noted, means are reported where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Differences in response distributions was determined using a 2-tailed Mann-Whitney test, using a significance threshold of 0.05; all significant comparisons are in bold.

[a] Negative outcomes.

TABLE 2.
Comparison of First-Generation college students (1st-Gen) and Continuing students in response to survey questions focused on experience with remote learning (1–6), balancing home and school responsibilities (7–13) and financial challenges (14–19).

Survey Question	1st-Gen (*N* = 302) mean ± SE	Continuing (*N* = 479) mean ± SE	Z-score	*p* value
1. My transition to remote learning was easy	**2.15 ± 0.047**[a]	**2.26 ± 0.036**[a]	**-2.298**[a]	**0.022**[a]
2. I am satisfied with remote instruction	2.44 ± 0.042	2.46 ± 0.033	-0.707	0.479
3. Remote instruction increased my workload	**2.87 ± 0.045**[a]	**2.7 ± 0.035**[a]	**-3.091**[a]	**0.002**[a]
4. Remote instruction reduces my ability to succeed	2.85 ± 0.045	2.89 ± 0.037	-0.486	0.627
5. Access to technology reduces my ability to participate in remote instruction	**2.42 ± 0.050**[a]	**1.92 ± 0.037**[a]	**-7.593**[a]	**0.000**[a]
6. Remote instruction during COVID increased my interest in taking more remote classes	2.08 ± 0.052	1.95 ± 0.039	-1.899	0.058
7. I work more (e.g., employment) now than before COVID-19.	**2.29 ± 0.050**[a]	**2.12 ± 0.037**[a]	**-2.927**[a]	**0.003**[a]
8. I have less time to devote to my schoolwork	**2.67 ± 0.050**[a]	**2.33 ± 0.037**[a]	**-5.458**[a]	**0.000**[a]
9. I have less ability to focus on my schoolwork	3.43 ± 0.042	3.33 ± 0.036	-1.63	0.103
10. I live with other students engaged in remote learning (Yes=1, No=2)	1.41 ± 0.027	1.44 ± 0.022	-0.934	0.350
11. I help my siblings or other members of my household with remote learning	**2.88 ± 0.057**[a]	**2.34 ± 0.044**[a]	**-7.488**[a]	**0.000**[a]
12. It is harder for me to balance schoolwork with my household responsibilities	**3.17 ± 0.049**[a]	**2.85 ± 0.039**[a]	**-5.314**[a]	**0.000**[a]
13. My living situation limits my ability to participate in remote instruction	**2.71 ± 0.051**[a]	**2.29 ± 0.039**[a]	**-6.642**[a]	**0.000**[a]
14. Prior to COVID-19 my family was financially secure	**2.76 ± 0.037**[a]	**3.26 ± 0.030**[a]	**-10.294**[a]	**0.000**[a]
15. My household has financial resources to cover expenses for the next 2-3 months	**2.43 ± 0.047**[a]	**3.07 ± 0.036**[a]	**-10.441**[a]	**0.000**[a]
16. My family has health insurance (Yes=1, No=2)	**1.28 ± 0.025**[a]	**1.06 ± 0.010**[a]	**-8.896**[a]	**0.000**[a]
17. My access to quality food was better at school	**2.89 ± 0.051**[a]	**2.67 ± 0.039**[a]	**-3.513**[a]	**0.000**[a]
18. How COVID-19 impacted food availability in your household (Decrease=1, No Change=2, Increase=3)	**1.80 ± 0.034**[a]	**1.91 ± 0.023**[a]	**-3.032**[a]	**0.002**[a]
19. How COVID-19 impacted food quality in your household (Decrease=1, No Change=2, Increase=3)	**1.66 ± 0.032**[a]	**1.83 ± 0.021**[a]	**-4.720**[a]	**0.000**[a]

Except where noted, means are reported where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Differences in response distributions was determined using a 2-tailed Mann-Whitney test, using a significance threshold of 0.05; all significant comparisons are in bold.

[a] Negative outcomes.

TABLE 3.
Comparison of URM and non-URM students in response to survey questions focused on experience with remote learning (1–6), balancing home and school responsibilities (7–13) and financial challenges (14–19).

Survey Question	**URM (*N* = 423) mean** ± SE	**non-URM (*N* = 483) mean ± SE**	**Z-score**	***p* value**
1. My transition to remote learning was easy	**2.13 ± 0.039[a]**	**2.31 ± 0.037[a]**	**-3.9[a]**	**0.000[a]**
2. I am satisfied with remote instruction	2.43 ± 0.036	2.47 ± 0.034	-1.071	0.284
3. Remote instruction increased my workload	**2.85 ± 0.039[a]**	**2.66 ± 0.036[a]**	**-3.635[a]**	**0.000[a]**
4. Remote instruction reduces my ability to succeed	2.89 ± 0.039	2.83 ± 0.037	-1.076	0.282
5. Access to technology reduces my ability to participate in remote instruction	**2.29 ± 0.042[a]**	**1.96 ± 0.039[a]**	**-5.963[a]**	**0.000[a]**
6. Remote instruction during COVID increased my interest in taking more remote classes	1.97 ± 0.042	2.05 ± 0.041	-1.198	0.231
7. I work more (e.g., employment) now than before COVID-19.	**2.26 ± 0.042[a]**	**2.11 ± 0.037[a]**	**-2.797[a]**	**0.005[a]**
8. I have less time to devote to my schoolwork	**2.62 ± 0.042[a]**	**2.31 ± 0.038[a]**	**-5.353[a]**	**0.000[a]**
9. I have less ability to focus on my schoolwork	**3.45 ± 0.035[a]**	**3.25 ± 0.038[a]**	**-3.846[a]**	**0.000[a]**
10. I live with other students engaged in remote learning (Yes=1, No=2)	**1.37 ± 0.023[a]**	**1.49 ± 0.022[a]**	**-3.628[a]**	**0.000[a]**
11. I help my siblings or other members of my household with remote learning	**2.79 ± 0.049[a]**	**2.32 ± 0.045[a]**	**-7.145[a]**	**0.000[a]**
12. It is harder for me to balance schoolwork with my household responsibilities	**3.12 ± 0.041[a]**	**2.84 ± 0.041[a]**	**-4.718[a]**	**0.000[a]**
13. My living situation limits my ability to participate in remote instruction	**2.58 ± 0.043[a]**	**2.32 ± 0.041[a]**	**-4.283[a]**	**0.000[a]**
14. Prior to COVID-19 my family was financially secure	**2.89 ± 0.033[a]**	**3.22 ± 0.033[a]**	**-7.282[a]**	**0.000[a]**
15. My household has financial resources to cover expenses for the next 2-3 months	**2.68 ± 0.040[a]**	**2.98 ± 0.041[a]**	**-5.795[a]**	**0.000[a]**
16. My family has health insurance (Yes=1, No=2)	**1.22 ± 0.020[a]**	**1.07 ± 0.013[a]**	**-6.103[a]**	**0.000[a]**
17. My access to quality food was better at school	**2.85 ± 0.043[a]**	**2.67 ± 0.044[a]**	**-2.824[a]**	**0.005[a]**
18. How COVID-19 impacted food availability in your household (Decrease=1, No Change=2, Increase=3)	**1.83 ± 0.029[a]**	**1.91 ± 0.025[a]**	**-2.495[a]**	**0.013[a]**
19. How COVID-19 impacted food quality in your household (Decrease=1, No Change=2, Increase=3)	1.74 ± 0.026	1.79 ± 0.024	-1.755	0.079

Except where noted, means are reported where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Differences in response distributions was determined using a 2-tailed Mann-Whitney test, using a significance threshold of 0.05; ; all significant comparisons are in bold.
[a] Negative outcomes.
URM = under-represented minority.

TABLE 4.
Comparison of intersectionality of 1) STEM URM (n = 238) and STEM non-URM (n = 247) students and 2) non-STEM URM (n = 158) and non-STEM non-URM (n = 167) students in response to survey questions focused on experience with remote learning (1–6), balancing home and school responsibilities (7–13) and financial challenges (14–19).

Survey Question	STEM				NON-STEM			
	URM (n = 238)	Non-URM (n = 247)	Z-score	p value	URM (n = 158)	Non-URM (n = 167)	Z-score	p value
1. My transition to remote learning was easy	**2.15 ± 0.05[a]**	**2.39 ± 0.05[a]**	**-3.526[a]**	**0.000[a]**	**2.12 ± 0.07**	**2.16 ± 0.07**	**-0.516**	**0.606**
2. I am satisfied with remote instruction	2.43 ± 0.05	2.53 ± 0.04	-1.470	0.142	2.45 ± 0.06	2.33 ± 0.06	-1.413	0.158
3. Remote instruction increased my workload	**2.90 ± 0.05[a]**	**2.67 ± 0.05[a]**	**-3.417[a]**	**0.001[a]**	**2.79 ± 0.07**	**2.71 ± 0.06**	**-0.994**	**0.320**
4. Remote instruction reduces my ability to succeed	2.88 ± 0.05	2.83 ± 0.05	-0.671	0.502	2.83 ± 0.07	2.98 ± 0.06	-1.562	0.118
5. Access to technology reduces my ability to participate in remote instruction	**2.22 ± 0.06[a]**	**1.89 ± 0.05[a]**	**-4.276[a]**	**0.000[a]**	**2.41 ± 0.07[a]**	**2.04 ± 0.07[a]**	**-3.994[a]**	**0.000[a]**
6. Remote instruction during COVID increased my interest in taking more remote classes	**1.92 ± 0.05[a]**	**2.09 ± 0.06[a]**	**-1.956[a]**	**0.050[a]**	**2.03 ± 0.07**	**1.90 ± 0.07**	**-1.155**	**0.248**
7. I work more (e.g., employment) now than before COVID-19.	2.16 ± 0.05	2.09 ± 0.05	-1.151	0.250	2.41 ± 0.08[a]	2.11 ± 0.07[a]	-2.876[a]	0.004[a]
8. I have less time to devote to my schoolwork	**2.56 ± 0.06[a]**	**2.31 ± 0.05[a]**	**-3.215[a]**	**0.001[a]**	**2.66 ± 0.07[a]**	**2.31 ± 0.06[a]**	**-3.853[a]**	**0.000[a]**
9. I have less ability to focus on my schoolwork	**3.46 ± 0.05[a]**	**3.31 ± 0.05[a]**	**-2.417[a]**	**0.016[a]**	**3.41 ± 0.06**	**3.31 ± 0.06**	**-1.006**	**0.314**
10. I live with other students engaged in remote learning (Yes=1, No=2)	**1.35 ± 0.03[a]**	**1.47 ± 0.03[a]**	**-2.716[a]**	**0.007[a]**	**1.36 ± 0.04[a]**	**1.51 ± 0.04[a]**	**-2.748[a]**	**0.006[a]**
11. I help my siblings or other members of my household with remote learning	**2.75 ± 0.06[a]**	**2.35 ± 0.06[a]**	**-4.372[a]**	**0.000[a]**	**2.96 ± 0.08[a]**	**2.23 ± 0.07[a]**	**-6.296[a]**	**0.000[a]**
12. It is harder for me to balance schoolwork with my household responsibilities	**3.11 ± 0.05[a]**	**2.77 ± 0.06[a]**	**-4.232[a]**	**0.000[a]**	**3.13 ± 0.07[a]**	**2.94 ± 0.07[a]**	**-2.090[a]**	**0.037[a]**
13. My living situation limits my ability to participate in remote instruction	**2.50 ± 0.06[a]**	**2.25 ± 0.06[a]**	**-3.125[a]**	**0.002[a]**	**2.71 ± 0.07[a]**	**2.38 ± 0.07[a]**	**-3.202[a]**	**0.001[a]**
14. Prior to COVID-19 my family was financially secure	**2.96 ± 0.04[a]**	**3.24 ± 0.04[a]**	**-4.676[a]**	**0.000[a]**	**2.81 ± 0.06[a]**	**3.18 ± 0.06[a]**	**-4.676[a]**	**0.000[a]**
15. My household has financial resources to cover expenses for the next 2-3 months	**2.79 ± 0.05[a]**	**3.00 ± 0.06[a]**	**-3.253[a]**	**0.001[a]**	**2.48 ± 0.07[a]**	**2.88 ± 0.07[a]**	**-4.276[a]**	**0.000[a]**
16. My family has health insurance (Yes=1, No=2)	**1.17 ± 0.02[a]**	**1.06 ± 0.02[a]**	**-3.889[a]**	**0.000[a]**	**1.29 ± 0.04[a]**	**1.07 ± 0.02[a]**	**-5.181[a]**	**0.000[a]**
17. My access to quality food was better at school	**2.85 ± 0.06[a]**	**2.69 ± 0.06[a]**	**-2.015[a]**	**0.044[a]**	**2.78 ± 0.07**	**2.75 ± 0.07**	**-0.318**	**0.750**
18. How COVID-19 impacted food availability in your household (Decrease=1, No Change=2, Increase=3)	1.83 ± 0.04	1.92 ± 0.03	-1.865	0.062	1.81 ± 0.05	1.90 ± 0.04	-1.564	0.118
19. How COVID-19 impacted food quality in your household (Decrease=1, No Change=2, Increase=3)	1.80 ± 0.03	1.81 ± 0.03	-0.202	0.840	1.66 ± 0.05[a]	1.77 ± 0.04[a]	-2.018[a]	0.044[a]

Except where noted, means are reported where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Differences in response distributions was determined using a 2-tailed Mann-Whitney test, using a significance threshold of 0.05; all significant comparisons are in bold, with negative outcomes highlighted in grey.

[a] Negative outcomes.

TABLE 5.
Comparison of intersectionality of 1) STEM URM First-Generation (1st-Gen) and STEM Continuing students and 2) non-STEM URM First-Generation and STEM Continuing students in response to survey questions focused on experience with remote learning (1–6), balancing home and school responsibilities (7–13) and financial challenges (14–19).

Survey Question	STEM				Non-STEM			
	1st-Gen (*n* = 178)	Continuing (*n* = 309)	Z-score	*p* value	1st-Gen (*n* = 137)	Continuing (*n* = 188)	Z-score	*p* value
1. My transition to remote learning was easy	**2.16 ± 0.06[a]**	**2.34 ± 0.04[a]**	**-2.577 [a]**	**0.010 [a]**	**2.12 ± 0.08**	**2.15 ± 0.06**	**-0.596**	**0.551**
2. I am satisfied with remote instruction	2.46 ± 0.05	2.50 ± 0.04	-0.848	0.397	2.36 ± 0.07	2.40 ± 0.05	-0.410	0.682
3. Remote instruction increased my workload	**2.88 ± 0.06[a]**	**2.73 ± 0.04[a]**	**-2.183 [a]**	**0.029 [a]**	**2.86 ± 0.07 [a]**	**2.68 ± 0.06 [a]**	**-2.139 [a]**	**0.032 [a]**
4. Remote instruction reduces my ability to succeed	2.86 ± 0.06	2.84 ± 0.05	-0.223	0.823	2.85 ± 0.07	2.95 ± 0.06	-1.002	0.316
5. Access to technology reduces my ability to participate in remote instruction	**2.34 ± 0.06[a]**	**1.87 ± 0.05[a]**	**-5.710 [a]**	**0.000 [a]**	**2.49 ± 0.08 [a]**	**2.03 ± 0.06 [a]**	**-4.508 [a]**	**0.000 [a]**
6. Remote instruction during COVID increased my interest in taking more remote classes	2.01 ± 0.06	2.02 ± 0.05	-0.127	0.899	2.14 ± 0.08 [a]	1.84 ± 0.06 [a]	-2.523 [a]	0.012 [a]
7. I work more (e.g., employment) now than before COVID-19.	**2.22 ± 0.06[a]**	**2.07 ± 0.05[a]**	**-2.164 [a]**	**0.030 [a]**	**2.37 ± 0.08**	**2.17 ± 0.06**	**-1.946**	**0.052**
8. I have less time to devote to my schoolwork	**2.65 ± 0.06[a]**	**2.30 ± 0.05[a]**	**-4.389 [a]**	**0.000 [a]**	**2.65 ± 0.08 [a]**	**2.35 ± 0.06 [a]**	**-3.186 [a]**	**0.001 [a]**
9. I have less ability to focus on my schoolwork	3.46 ± 0.05	3.34 ± 0.04	-1.583	0.114	3.39 ± 0.07	3.34 ± 0.06	-0.306	0.759
10. I live with other students engaged in remote learning (Yes=1, No=2)	1.40 ± 0.04	1.42 ± 0.03	-0.349	0.727	1.39 ± 0.04	1.48 ± 0.04	-1.590	0.112
11. I help my siblings or other members of my household with remote learning	**2.80 ± 0.08[a]**	**2.40 ± 0.06[a]**	**-4.274 [a]**	**0.000 [a]**	**2.99 ± 0.08 [a]**	**2.29 ± 0.07 [a]**	**-6.085 [a]**	**0.000[a]**
12. It is harder for me to balance schoolwork with my household responsibilities	**3.15 ± 0.07[a]**	**2.81 ± 0.05[a]**	**-4.365 [a]**	**0.000 [a]**	**3.16 ± 0.07 [a]**	**2.94 ± 0.06 [a]**	**-2.437 [a]**	**0.015[a]**
13. My living situation limits my ability to participate in remote instruction	**2.61 ± 0.07[a]**	**2.22 ± 0.05[a]**	**-4.628 [a]**	**0.000 [a]**	**2.81 ± 0.07 [a]**	**2.35 ± 0.07 [a]**	**-4.351 [a]**	**0.000[a]**
14. Prior to COVID-19 my family was financially secure	**2.79 ± 0.05[a]**	**3.29 ± 0.04[a]**	**-7.740 [a]**	**0.000 [a]**	**2.70 ± 0.06 [a]**	**3.20 ± 0.05 [a]**	**-6.419 [a]**	**0.000[a]**
15. My household has financial resources to cover expenses for the next 2-3 months	**2.51 ± 0.06[a]**	**3.12 ± 0.05[a]**	**-8.013 [a]**	**0.000 [a]**	**2.33 ± 0.07 [a]**	**2.94 ± 0.06 [a]**	**-5.969 [a]**	**0.000[a]**
16. My family has health insurance (Yes=1, No=2)	**1.24 ± 0.03[a]**	**1.05 ± 0.01[a]**	**-6.509 [a]**	**0.000 [a]**	**1.32 ± 0.04 [a]**	**1.09 ± 0.02 [a]**	**-5.311[a]**	**0.000[a]**
17. My access to quality food was better at school	**2.99 ± 0.07[a]**	**2.64 ± 0.05[a]**	**-4.195[a]**	**0.000 [a]**	**2.81 ± 0.08**	**2.74 ± 0.07**	**-0.721**	**0.471**
18. How COVID-19 impacted food availability in your household (Decrease=1, No Change=2, Increase=3)	1.82 ± 0.04	1.91 ± 0.03	-1.810	0.070	1.78 ± 0.06[a]	1.90 ± 0.04[a]	-2.046[a]	0.041[a]
19. How COVID-19 impacted food quality in your household (Decrease=1, No Change=2, Increase=3)	**1.70 ± 0.04[a]**	**1.87 ± 0.02[a]**	**-3.801[a]**	**0.000[a]**	**1.63 ± 0.05[a]**	**1.78 ± 0.04 [a]**	**-2.523[a]**	**0.012[a]**

Except where noted, means are reported where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Differences in response distributions was determined using a 2-tailed Mann-Whitney test, using a significance threshold of 0.05; all significant comparisons are in bold, with negative outcomes highlighted in gray.
[a] Negative outcomes.

TABLE 6.
Comparison of intersectionality of 1) First-Generation STEM and First-Generation non-STEM students and 2) Continuing STEM and Continuing non-STEM students in response to survey questions focused on experience with remote learning (1–6), balancing home and school responsibilities (7–13) and financial challenges (14–19).

Survey Question	First-Generation				Continuing			
	STEM (*n* = 178)	Non-STEM (*n* = 137)	Z-score	*p* value	STEM (*n* = 309)	Non-STEM (*n* = 188)	Z-score	*p* value
1. My transition to remote learning was easy	2.16 ± 0.06	2.12 ± 0.08	-0.817	0.414	**2.34 ± 0.04**	**2.15 ± 0.06**	**-2.362**	**0.018**
2. I am satisfied with remote instruction	2.46 ± 0.05	2.36 ± 0.07	-1.050	0.294	2.50 ± 0.04	2.40 ± 0.05	-1.612	0.107
3. Remote instruction increased my workload	2.88 ± 0.06	2.86 ± 0.07	-0.304	0.761	2.73 ± 0.04	2.68 ± 0.06	-0.730	0.465
4. Remote instruction reduces my ability to succeed	2.86 ± 0.06	2.85 ± 0.07	-0.001	0.999	2.84 ± 0.05	2.95 ± 0.06	-1.449	0.147
5. Access to technology reduces my ability to participate in remote instruction	2.34 ± 0.06	2.49 ± 0.08	-1.504	0.133	**1.87 ± 0.05**	**2.03 ± 0.06**	**-2.066**	**0.039**
6. Remote instruction during COVID increased my interest in taking more remote classes	2.01 ± 0.06	2.14 ± 0.08	-0.878	0.380	**2.02 ± 0.05**	**1.84 ± 0.06**	**-1.966**	**0.049**
7. I work more (e.g., employment) now than before COVID-19.	2.22 ± 0.06	2.37 ± 0.08	-1.319	0.187	2.07 ± 0.05	2.17 ± 0.06	-1.145	0.252
8. I have less time to devote to my schoolwork	2.65 ± 0.06	2.65 ± 0.08	-0.013	0.990	2.30 ± 0.05	2.35 ± 0.06	-0.579	0.563
9. I have less ability to focus on my schoolwork	3.46 ± 0.05	3.39 ± 0.07	-0.750	0.453	3.34 ± 0.04	3.34 ± 0.06	-0.293	0.769
10. I live with other students engaged in remote learning (Yes=1, No=2)	1.40 ± 0.04	1.39 ± 0.04	-0.265	0.791	1.42 ± 0.03	1.48 ± 0.04	-1.261	0.207
11. I help my siblings or other members of my household with remote learning	2.80 ± 0.08	2.99 ± 0.08	-1.634	0.102	2.40 ± 0.06	2.29 ± 0.07	-1.211	0.226
12. It is harder for me to balance schoolwork with my household responsibilities	3.15 ± 0.07	3.16 ± 0.07	-0.046	0.964	2.81 ± 0.05	2.94 ± 0.06	-1.568	0.117
13. My living situation limits my ability to participate in remote instruction	2.61 ± 0.07	2.81 ± 0.07	-1.934	0.053	2.22 ± 0.05	2.35 ± 0.07	-1.507	0.132
14. Prior to COVID-19 my family was financially secure	2.79 ± 0.05	2.70 ± 0.06	-1.049	0.294	3.29 ± 0.04	3.20 ± 0.05	-1.045	0.296
15. My household has financial resources to cover expenses for the next 2-3 months	2.51 ± 0.06	2.33 ± 0.07	-1.882	0.060	**3.12 ± 0.05**	**2.94 ± 0.06**	**-2.388**	**0.017**
16. My family has health insurance (Yes=1, No=2)	1.24 ± 0.03	1.32 ± 0.04	-1.437	0.151	1.05 ± 0.01	1.09 ± 0.02	-1.805	0.071
17. My access to quality food was better at school	2.99 ± 0.07	2.81 ± 0.08	-1.627	0.104	2.64 ± 0.05	2.74 ± 0.07	-1.245	0.213
18. How COVID-19 impacted food availability in your household (Decrease=1, No Change=2, Increase=3)	1.82 ± 0.04	1.78 ± 0.06	-0.868	0.386	1.91 ± 0.03	1.90 ± 0.04	-0.142	0.887
19. How COVID-19 impacted food quality in your household (Decrease=1, No Change=2, Increase=3)	1.70 ± 0.04	1.63 ± 0.05	-1.195	0.232	**1.87 ± 0.02**	**1.78 ± 0.04**	**-2.240**	**0.025**

Except where noted, means are reported where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Differences in response distributions was determined using a 2-tailed Mann-Whitney test, using a significance threshold of 0.05; all significant comparisons are in bold.
[a] Negative outcomes.

TABLE 7.
Comparison of intersectionality of 1) First-Generation URM and First-Generation non-URM students and 2) Continuing URM and Continuing non-URM students in response to survey questions focused on experience with remote learning (1–6), balancing home and school responsibilities (7–13) and financial challenges (14–19).

Survey Question	First-Generation				Continuing			
	URM (n = 234)	Non-URM (n = 86)	Z-score	p value	URM (n = 172)	Non-URM (n = 345)	Z-score	p value
1. My transition to remote learning was easy	2.12 ± 0.06	2.20 ± 0.08	-0.939	0.348	**2.15 ± 0.06** [a]	**2.31 ± 0.04** [a]	**-2.093** [a]	**0.036** [a]
2. I am satisfied with remote instruction	2.43 ± 0.05	2.40 ± 0.07	-0.243	0.808	2.46 ± 0.05	2.46 ± 0.04	-0.081	0.935
3. Remote instruction increased my workload	2.88 ± 0.05	2.85 ± 0.09	-0.453	0.651	**2.83 ± 0.06** [a]	**2.66 ± 0.04** [a]	**-2.585** [a]	**0.010** [a]
4. Remote instruction reduces my ability to succeed	2.81 ± 0.05	2.95 ± 0.08	-1.262	0.207	2.91 ± 0.06	2.87 ± 0.04	-0.429	0.668
5. Access to technology reduces my ability to participate in remote instruction	2.44 ± 0.06	2.31 ± 0.10	-1.232	0.218	**2.09 ± 0.07** [a]	**1.84 ± 0.04** [a]	**-3.283** [a]	**0.001** [a]
6. Remote instruction during COVID increased my interest in taking more remote classes	2.08 ± 0.06	2.07 ± 0.10	-0.002	0.998	1.85 ± 0.06	2.00 ± 0.05	-1.633	0.102
7. I work more (e.g., employment) now than before COVID-19.	2.33 ± 0.06	2.15 ± 0.09	-1.542	0.123	2.16 ± 0.06	2.09 ± 0.04	-0.989	0.323
8. I have less time to devote to my schoolwork	2.67 ± 0.06	2.62 ± 0.10	-0.453	0.650	**2.52 ± 0.07** [a]	**2.22 ± 0.04** [a]	**-3.777** [a]	**0.000** [a]
9. I have less ability to focus on my schoolwork	3.46 ± 0.05	3.38 ± 0.08	-1.287	0.198	3.42 ± 0.06	3.29 ± 0.04	-1.754	0.079
10. I live with other students engaged in remote learning (Yes=1, No=2)	1.38 ± 0.03	1.48 ± 0.05	-1.744	0.081	1.35 ± 0.04	1.48 ± 0.03	-2.790	**0.005**
11. I help my siblings or other members of my household with remote learning	**2.97 ± 0.06** [a]	**2.67 ± 0.11** [a]	**-2.352** [a]	**0.019** [a]	**2.64 ± 0.08** [a]	**2.19 ± 0.05** [a]	**-4.794** [a]	**0.000** [a]
12. It is harder for me to balance school-work with my household responsibilities	3.19 ± 0.06	3.08 ± 0.10	-0.843	0.399	**3.02 ± 0.06** [a]	**2.76 ± 0.05** [a]	**-3.163** [a]	**0.002** [a]
13. My living situation limits my ability to participate in remote instruction	2.71 ± 0.06	2.68 ± 0.10	-0.267	0.789	**2.40 ± 0.07** [a]	**2.20 ± 0.05** [a]	**-2.352** [a]	**0.019** [a]
14. Prior to COVID-19 my family was financially secure	2.74 ± 0.04	2.79 ± 0.07	-0.326	0.744	**3.13 ± 0.05** [a]	**3.32 ± 0.04** [a]	**-3.331** [a]	**0.001** [a]
15. My household has financial resources to cover expenses for the next 2-3 months	2.46 ± 0.05	2.36 ± 0.10	-0.792	0.428	**2.95 ± 0.06** [a]	**3.12 ± 0.04** [a]	**-2.574** [a]	**0.010** [a]
16. My family has health insurance (Yes=1, No=2)	**1.32 ± 0.03** [a]	**1.15 ± 0.04** [a]	**-3.109** [a]	**0.002** [a]	**1.09 ± 0.02** [a]	**1.04 ± 0.01** [a]	**-2.401** [a]	**0.016** [a]
17. My access to quality food was better at school	2.90 ± 0.06	2.89 ± 0.10	-0.067	0.947	2.71 ± 0.07	2.66 ± 0.05	-0.688	0.491
18. How COVID-19 impacted food availability in your household (Decrease=1, No Change=2, Increase=3)	1.77 ± 0.04	1.86 ± 0.07	-1.161	0.246	1.88 ± 0.04	1.92 ± 0.03	-0.879	0.379
19. How COVID-19 impacted food quality in your household (Decrease=1, No Change=2, Increase=3)	1.67 ± 0.04	1.64 ± 0.06	-0.246	0.806	1.82 ± 0.04	1.83 ± 0.02	-0.293	0.770

Except where noted, means are reported where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Differences in response distributions was determined using a 2-tailed Mann-Whitney test, using a significance threshold of 0.05; all significant comparisons are in bold.
[a] Negative outcomes.

TABLE 8.
Comparison of intersectionality of 1) URM First-Generation and URM Continuing students and 2) non-URM First-Generation and non-URM Continuing students in response to survey questions focused on experience with remote learning (1–6), balancing home and school responsibilities (7–13) and financial challenges (14–19).

Survey Question	URM				Non-URM			
	1st-Gen (n = 234)	Continuing (n = 172)	Z-score	p value	1st-Gen (n = 86)	Continuing (n = 345)	Z-score	p value
1. My transition to remote learning was easy	2.12 ± 0.06	2.15 ± 0.06	-0.747	0.455	2.20 ± 0.08	2.31 ± 0.04	-1.336	0.182
2. I am satisfied with remote instruction	2.43 ± 0.05	2.46 ± 0.05	-0.550	0.583	2.40 ± 0.07	2.46 ± 0.04	-0.662	0.508
3. Remote instruction increased my workload	2.88 ± 0.05	2.83 ± 0.06	-0.716	0.474	**2.85 ± 0.09[a]**	**2.66 ± 0.04[a]**	**-2.104[a]**	**0.035[a]**
4. Remote instruction reduces my ability to succeed	2.81 ± 0.05	2.91 ± 0.06	-1.018	0.309	2.95 ± 0.08	2.87 ± 0.04	-0.754	0.451
5. Access to technology reduces my ability to participate in remote instruction	**2.44 ± 0.06[a]**	**2.09 ± 0.07[a]**	**-3.918[a]**	**0.000[a]**	**2.31 ± 0.10[a]**	**1.84 ± 0.04[a]**	**-4.385[a]**	**0.000[a]**
6. Remote instruction during COVID increased my interest in taking more remote classes	**2.08 ± 0.06[a]**	**1.85 ± 0.06[a]**	**-2.293[a]**	**0.022[a]**	2.07 ± 0.10	2.00 ± 0.05	-0.625	0.532
7. I work more (e.g., employment) now than before COVID-19.	2.33 ± 0.06	2.16 ± 0.06	-1.887	0.059	2.15 ± 0.09	2.09 ± 0.04	-0.687	0.492
8. I have less time to devote to my schoolwork	2.67 ± 0.06	2.52 ± 0.07	-1.781	0.075	**2.62 ± 0.10[a]**	**2.22 ± 0.04[a]**	**-3.835[a]**	**0.000[a]**
9. I have less ability to focus on my schoolwork	3.46 ± 0.05	3.42 ± 0.06	-0.512	0.608	3.38 ± 0.08	3.29 ± 0.04	-0.571	0.568
10. I live with other students engaged in remote learning (Yes=1, No=2)	1.38 ± 0.03	1.35 ± 0.04	-0.419	0.675	1.48 ± 0.05	1.48 ± 0.03	-0.022	0.983
11. I help my siblings or other members of my household with remote learning	**2.97 ± 0.06[a]**	**2.64 ± 0.08[a]**	**-3.296[a]**	**0.001[a]**	**2.67 ± 0.11[a]**	**2.19 ± 0.05[a]**	**-3.850[a]**	**0.000[a]**
12. It is harder for me to balance schoolwork with my household responsibilities	**3.19 ± 0.06[a]**	**3.02 ± 0.06[a]**	**-2.209[a]**	**0.027[a]**	**3.08 ± 0.10[a]**	**2.76 ± 0.05[a]**	**-3.210[a]**	**0.001[a]**
13. My living situation limits my ability to participate in remote instruction	**2.71 ± 0.06[a]**	**2.40 ± 0.07[a]**	**-3.435[a]**	**0.001[a]**	**2.68 ± 0.10[a]**	**2.20 ± 0.05[a]**	**-4.294[a]**	**0.000[a]**
14. Prior to COVID-19 my family was financially secure	**2.74 ± 0.04[a]**	**3.13 ± 0.05[a]**	**-5.739[a]**	**0.000[a]**	**2.79 ± 0.07[a]**	**3.32 ± 0.04[a]**	**-6.363[a]**	**0.000[a]**
15. My household has financial resources to cover expenses for the next 2-3 months	**2.46 ± 0.05[a]**	**2.95 ± 0.06[a]**	**-5.967[a]**	**0.000[a]**	**2.36 ± 0.10[a]**	**3.12 ± 0.04[a]**	**-6.890[a]**	**0.000[a]**
16. My family has health insurance (Yes=1, No=2)	**1.32 ± 0.03[a]**	**1.09 ± 0.02[a]**	**-5.494[a]**	**0.000[a]**	**1.15 ± 0.04[a]**	**1.04 ± 0.01[a]**	**-3.744[a]**	**0.000[a]**
17. My access to quality food was better at school	**2.90 ± 0.06[a]**	**2.71 ± 0.07[a]**	**-2.090[a]**	**0.037[a]**	**2.89 ± 0.10[a]**	**2.66 ± 0.05[a]**	**-2.183[a]**	**0.029[a]**
18. How COVID-19 impacted food availability in your household (Decrease=1, No Change=2, Increase=3)	**1.77 ± 0.04[a]**	**1.88 ± 0.04[a]**	**-1.944[a]**	**0.052[a]**	1.86 ± 0.07	1.92 ± 0.03	-1.068	0.286
19. How COVID-19 impacted food quality in your household (Decrease=1, No Change=2, Increase=3)	**1.67 ± 0.04[a]**	**1.82 ± 0.04[a]**	**-2.932[a]**	**0.003[a]**	**1.64 ± 0.06[a]**	**1.83 ± 0.02[a]**	**-3.305[a]**	**0.001[a]**

Except where noted, means are reported where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Differences in response distributions was determined using a 2-tailed Mann-Whitney test, using a significance threshold of 0.05; all significant comparisons are in bold.
[a] Negative outcomes.

TABLE 9.
Comparison of intersectionality of 1) URM STEM and URM non-STEM students and 2) non-URM STEM and non-URM non-STEM students in response to survey questions focused on experience with remote learning (1–6), balancing home and school responsibilities (7–13) and financial challenges (14–19).

Survey Question	URM				Non-URM			
	STEM (*n* = 238)	Non-STEM (*n* = 158)	Z-score	*p* value	STEM (*n* = 247)	Non-STEM (*n* = 167)	Z-score	*p* value
1. My transition to remote learning was easy	2.15 ± 0.05	2.12 ± 0.07	-0.570	0.569	**2.39 ± 0.05**	**2.16 ± 0.07**	**-2.768**	**0.006**
2. I am satisfied with remote instruction	2.43 ± 0.05	2.45 ± 0.06	-0.201	0.840	**2.53 ± 0.04**	**2.33 ± 0.06**	**-2.713**	**0.007**
3. Remote instruction increased my workload	2.90 ± 0.05	2.79 ± 0.07	-1.376	0.169	2.67 ± 0.05	2.71 ± 0.06	-0.594	0.552
4. Remote instruction reduces my ability to succeed	2.88 ± 0.05	2.83 ± 0.07	-0.556	0.578	2.83 ± 0.05	2.98 ± 0.06	-1.895	0.058
5. Access to technology reduces my ability to participate in remote instruction	**2.22 ± 0.06**	**2.41 ± 0.07**	**-2.187**	**0.029**	1.89 ± 0.05	2.04 ± 0.07	-1.636	0.102
6. Remote instruction during COVID increased my interest in taking more remote classes	1.92 ± 0.05	2.03 ± 0.07	-0.898	0.369	**2.09 ± 0.06**	**1.90 ± 0.07**	**-2.105**	**0.035**
7. I work more (e.g., employment) now than before COVID-19.	**2.16 ± 0.05**	**2.41 ± 0.08**	**-2.568**	**0.010**	2.09 ± 0.05	2.11 ± 0.07	-0.238	0.812
8. I have less time to devote to my schoolwork	2.56 ± 0.06	2.66 ± 0.07	-1.191	0.234	2.31 ± 0.05	2.31 ± 0.06	-0.140	0.889
9. I have less ability to focus on my schoolwork	3.46 ± 0.05	3.41 ± 0.06	-0.630	0.529	3.31 ± 0.05	3.31 ± 0.06	-0.339	0.735
10. I live with other students engaged in remote learning (Yes=1, No=2)	1.35 ± 0.03	1.36 ± 0.04	-0.261	0.794	1.47 ± 0.03	1.51 ± 0.04	-0.862	0.389
11. I help my siblings or other members of my household with remote learning	**2.75 ± 0.06**	**2.96 ± 0.08**	**-2.022**	**0.043**	2.35 ± 0.06	2.23 ± 0.07	-1.063	0.288
12. It is harder for me to balance schoolwork with my household responsibilities	3.11 ± 0.05	3.13 ± 0.07	-0.332	0.740	2.77 ± 0.06	2.94 ± 0.07	-1.872	0.061
13. My living situation limits my ability to participate in remote instruction	**2.50 ± 0.06**	**2.71 ± 0.07**	**-2.316**	**0.021**	2.25 ± 0.06	2.38 ± 0.07	-1.421	0.155
14. Prior to COVID-19 my family was financially secure	**2.96 ± 0.04**	**2.81 ± 0.06**	**-1.980**	**0.048**	3.24 ± 0.04	3.18 ± 0.06	-0.773	0.440
15. My household has financial resources to cover expenses for the next 2-3 months	**2.79 ± 0.05**	**2.48 ± 0.07**	**-3.597**	**0.000**	3.00 ± 0.06	2.88 ± 0.07	-1.289	0.197
16. My family has health insurance (Yes=1, No=2)	**1.17 ± 0.02**	**1.29 ± 0.04**	**-2.786**	**0.005**	1.06 ± 0.02	1.07 ± 0.02	-0.460	0.645
17. My access to quality food was better at school	2.85 ± 0.06	2.78 ± 0.07	-0.700	0.484	2.69 ± 0.06	2.75 ± 0.07	-0.704	0.482
18. How COVID-19 impacted food availability in your household (Decrease=1, No Change=2, Increase=3)	1.83 ± 0.04	1.81 ± 0.05	-0.607	0.544	1.92 ± 0.03	1.90 ± 0.04	-0.337	0.736
19. How COVID-19 impacted food quality in your household (Decrease=1, No Change=2, Increase=3)	**1.80 ± 0.03**	**1.66 ± 0.05**	**-2.745**	**0.006**	1.81 ± 0.03	1.77 ± 0.04	-0.814	0.415

Except where noted, means are reported where 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree. Differences in response distributions was determined using a 2-tailed Mann-Whitney test, using a significance threshold of 0.05; all significant comparisons are in bold.
[a] Negative outcomes.

revealed worse outcomes for non-STEM URM students (*n* = 158) than for non-URM (*n* = 167) in 11 of 19 (57.9%) survey questions (Table 5). Unlike STEM students, however, there were no significant differences between URM and non-URM non-STEM majors in (i) ease of transition to remote learning, (ii) increased workload associated with remote learning , (iii) ability to focus on schoolwork, or (iv) access to healthy food choices. However, URM non-STEM students had significantly more employment hours and reduced food quality during stay-at-home orders than non-URM students.

STEM majors who are first-generation (*n* = 178) had worse outcomes across 13 of 19 (68.4%) survey questions than STEM majors who are continuing students (*n* = 309) (Table 5). First-generation and continuing STEM majors were only similar in (i) their satisfaction with remote learning, (ii) their belief that remote learning is limiting their ability to succeed, (iii) interest in further remote learning, (iv) ability to focus on schoolwork, (v) living in a household with other students engaged in remote learning, and (vi) food quantity at home. Similarly, non-STEM majors who are first-generation students (*n* = 137) had worse outcomes than non-STEM continuing students (*n* = 188) for 12 of 19 questions (63.2%) (Table 5). Unlike STEM students, there was no difference between non-STEM first-generation and continuing students in (i) ease of transition to remote learning, (ii) students working more hours, and (iii) better access to healthy food at school. Interestingly, non-STEM first-generation students expressed higher interest in further remote instruction. They also reported having reduced food quantity while at home during remote instruction.

First-generation intersectionalities

Across all 19 questions, there were no significant differences between first-generation STEM (*n* = 178) and first-generation non-STEM students (*n* = 137) (Table 6). However, continuing STEM majors (*n* = 309) had significantly better outcomes than continuing non-STEM majors (*n* = 188) for 5 of 19 questions (26.3%) (Table 6). Continuing STEM majors had greater ease of transition to remote learningand experienced fewer issues with access to technology, resulting in higher interest in further remote learning. Families of STEM students also had higher household financial resources and reported higher quality of food during the stay-at-home orders.

The experience of first-generation URM (*n* = 234) and non-URM (*n* = 86) students with remote learning was largely similar (Table 7). They only differed in first-generation URM students having higher expectations with helping family members with remote learning and being less likely to have health insurance . Interestingly, continuing URM students (*n* = 172) had worse outcomes in 10 out of 19 (52.6%) questions compared to continuing non-URM students (*n* = 345). In addition to the previous two categories, continuing URM students also fared worse in ease of transition to remote learning and increased workload, and were more limited by access to technology. In addition, continuing URM students reported less time to devote to schoolwork , struggled balancing schoolwork with household responsibilities, and had living situations that reduced their ability to focus. Continuing URM students were also less likely to have household financial resources to weather 2 to 3 months of stay-at-home orders and reported higher family financial security prior to the pandemic.

URM intersectionalities

Examining only URM students, results showed that first-generation URM students (*n* = 234) face significantly greater challenges compared to continuing URM students (*n* = 172) (Table 8). First-generation URM students had worse outcomes for all but 8 of the 19 questions. Both groups were similar in (i) the difficulty transitioning to remote learning, (ii) their satisfaction with remote class instruction, (iii) increased course workload due to remote instruction, (iv) remote instruction negatively affecting their ability to succeed, (v) increased hours at work, (vi) having less time to devote to schoolwork, (vii) having less ability to focus on schoolwork, and (viii) having other students in their household also engaging in remote learning. Similarly, non-URM first-generation (*n* = 86) have significantly worse outcomes than non-URM continuing students (*n* = 345) in 11 out of 19 (57.9%) questions. The challenges facing non-URM first-generation students were largely the same as URM first-generation students, except that there was no significant difference in (i) interest in taking more remote classes and (ii) the impact of COVID-19 on the quantity of food available in their household. However, non-URM first-generation students reported that remote instruction significantly increased their and had less time to devote to school work.

Interestingly, URM STEM students (*n* = 238) had significantly better outcomes than URM non-STEM students (*n* = 158) for 8 of 19 (42.1%) questions (Table 9). URM STEM students were less likely to be impacted by access to technology than URM non-STEM students. URM STEM students had fewer work hours, less responsibility for caring for siblings or family members, and were less likely to have living situations that reduced their ability to participant in remote instruction. Additionally, STEM URM were more likely to be financially secure prior to COVID-19, have financial resources to cover expenses during the stay-at-home order, more likely to have health insurance, and were less likely to experience changes in food quality compared to non-STEM URM students. In contrast, non-URM STEM students (*n* = 247) only had better outcomes than non-URM non-STEM students (*n* = 167) for 3 out of 19 (15.8%) questions, all of which were different from the URM STEM students. Overall, non-URM STEM students had less difficulty transitioning to online learning , were more satisfied with remote instruction , and were more interested in taking remote classes in the future.

Due to the strong similarities in responses of first-generation and URM students, we conducted a post hoc Pearson correlation test and identified a significant correlation in our dataset between being first-generation and URM.

Results of a shifting curriculum

A primary objective of the instructors in reenvisioning an in-person capstone lab course for remote instruction was to provide stability during uncertain times and deliver a meaningful, authentic research experience for the students. To understand the degree to which this objective was achieved, we engaged in a debriefing session at the end of the quarter to understand the process from the students' perspective. In this debriefing, the students identified four primary outcomes that defined their experience. First, although most students were initially disappointed with the shift to remote learning, all were satisfied with the outcome. Second, they indicated that the course provided stability during otherwise unpredictable times. Third, the students learned skills they may not have otherwise, particularly related to research design and survey development. Finally, students found the experience empowering, especially given the fact that they were the driving force behind the project and it kept them engaged with life sciences.

Given the rapid shift to remote instruction during the winter quarter, it is not surprising that most students were frustrated at what they perceived would result in lost opportunities to engage in research. As one student stated, "I definitely was disappointed that we weren't going to be able... go out into the field. I was excited to get out there and do some research." However, initial emotions changed through refocusing research on student experiences. For example, "a lot of us were… upset a little bit...that we weren't going to be able to go out to the field, but I think that kind of turned into, like, excitement because…we started to do COVID research, especially because that's...really relevant now." Another indicated, "I like, really like those [sic] projects now. So, I guess it worked out in the end."

Students recognized that the course could have been cancelled and that this alternative research experience during remote learning provided much needed stability. Importantly, the pedagogical shift not only met student expectations, but it exceeded them. Specifically, although students did not learn skills associated with field sampling and chemistry and genetic bench skills, students learned additional valuable social science and survey development skills that they may not have learned if the course had not gone remote. In particular, conversations around inequities in remote learning increased the construct validity of the study. Although they may not have learned about such nuances had the course gone as planned, such discussions were central as they developed the project. Moreover, the students enjoyed the process of designing the survey, in part because they were able to design questions based on their personal experiences, noting "we are seeing the disparities ourselves, and we know what to look for." As such, they were able to break down the unique ways that engaging in remote learning from home would impact URM and first-generation students. For example, many noted that families often do not understand what it takes to go to college. Without this experience, it is difficult for parents to appreciate the demands and challenges students face, particularly during the shift to remote instruction, where normal challenges are amplified, as noted above.

By empowering the students to be the driving force behind this project, students explained that the project kept them engaged and increased their interest in life sciences. In fact, 15 of 20 students continued to meet weekly during the summer—completely voluntarily—to see their research to completion. As one student stated, "that really just goes to show how something...really great can come from...not from nothing, but something we don't expect." Others had similar comments, noting that they would normally not have considered their survey as life science research, but now understand why it is. Perhaps most importantly, while their research focused on disparities in remote learning, students indicated that this experience made them more motivated to do research and bring awareness at the university level to health disparities, the original focus of the research practicum. This unexpected outcome demonstrates how authentic research experiences can translate beyond the topical focus of that experience. Moreover, these students, as co-authors on this paper, have seen their project through from its conception to the process of publication, all in less than 9 months.

DISCUSSION

It will take years to fully understand the impact of the shift to remote instruction in higher education forced by the COVID-19 pandemic. However, this study reveals that UCLA students experienced many challenges during remote instruction. These challenges mirror reports from media outlets (39) and school boards (40) about challenges experienced by K–12 students, particularly with respect to adapting to remote instruction, having adequate technology, and issues of food security.

Of particular concern, our results also document significant disparities in remote learning, with challenges that disproportionately impact URM and first-generation college students. Previous research prior to COVID-19 shows that Black and Latinx students are disadvantaged in online classes (41–43), a pattern that extends to COVID-related remote instruction, particularly for First-Generation and low-income students (35, 36). In questions spanning a range of student experiences with remote learning and COVID-19 related challenges, first-generation and URM respondents were significantly more disadvantaged in 15 of 19 and 14 of 19 questions, respectively. Moreover, analyses of intersectionalities show that these URM and first-generation students are particularly disadvantaged in remote learning associated with COVID-19, regardless of major. These disparities add to well-documented challenges facing these two vulnerable groups (44), suggesting that remote instruction could amplify already elevated STEM attrition rates of URM (8, 9) and first-generation students (31).

Shared Challenges and Inequities

The unprecedented shift to remote instruction forced by the COVID-19 pandemic had broad impacts across all undergraduate students at UCLA. Most respondents indicated that this transition was difficult, and that this experience with remote learning decreased their interest in further remote instruction (Fig. 1). This reduced interest likely results from the prevailing view that remote instruction increased student workloads and that their living situation limited their ability to participate in remote instruction, reducing their ability to succeed. Although decreased interest in remote instruction may be unique to student experience during COVID-19, this negative experience could limit further expansion of remote learning, a key strategic goal of many institutions (45).

Despite broadly shared student experiences, we documented substantial inequities associated with the shift to remote instruction. First, STEM students in this study were generally less satisfied with remote instruction compared to non-STEM students. STEM majors are particularly challenging, with six-year degree completion rates <40% even during in-person instruction (46). As such, it is perhaps unsurprising that these STEM students were less satisfied with remote learning. One potential explanation for this dissatisfaction is the inability to conduct hands-on laboratory courses, highly interactive classes that are a common feature of STEM curricula throughout higher education. While the exact causes of STEM student dissatisfaction are unclear, other emerging research also indicates unique challenges for STEM students impacting Fall 2020 enrollment and graduation plans (47).

However, not all disparities experienced by STEM students were negative. Intersectionality analysis showed that non-URM and continuing STEM student respondents actually had an easier time shifting to remote instruction and were more satisfied with the experience, potentially because of fewer issues they faced with access to technology. Interestingly, better outcomes for these STEM majors carried over to URM students, even though they had worse outcomes broadly. For example, although URM students in our study experienced significant challenges related to technology access compared to non-URM students, these URM STEM students were significantly less likely to experience these challenges than URM non-STEM students. Similarly, these URM STEM students had fewer challenges balancing home and school responsibilities and reported greater economic and food security than URM non-STEM students. It is unclear what drives this striking pattern. One possible explanation is that the URM STEM majors in this study may be more likely to come from families with fewer financial challenges, translating to better success in remote learning. *Post hoc* examination of student demographic data indicated that ~50% of URM STEM students had Pell Grants, compared to ~75% for URM non-STEM students. Although this difference provides indirect evidence that these URM STEM students are more financially secure, it is unclear whether URM students from more financially secure families are more likely to pursue STEM degrees in the first place, or whether increased financial security makes them more likely to persist in STEM, a question that merits further investigation.

Overall, however, URM and first-generation student respondents at UCLA were the most negatively impacted by the shift to remote learning. For example, although all comparison groups indicated that technology limited their participation to remote instruction to some degree, URM and first-generation students in this study were the most heavily impacted, a result confirmed through intersectionality analysis (Tables 4 and 5). Access to computers and the internet is a long-standing issue in minority populations (48). As such, minority populations are more likely than Whites to access the internet via mobile phone (49), potentially reducing student participation in remote learning. Because technological issues can lower student course satisfaction (50), UCLA increased the lending of laptops and mobile Wi-Fi hotspots and provided grants and loans for the purchase of technology. Despite these efforts to close the digital divide, technology still limited remote learning engagement of 42% of first-generation and 36.6% of URM students, a troubling figure both for further remote instruction during COVID-19 as well as remote learning more broadly. Of particular concern, early research on K-12 remote learning during COVID-19 remote shows that these challenges can have strong negative impacts on student performance. Given that improved class performance by URM STEM majors at UCLA results in increased STEM persistence (37), these temporary pandemic-related challenges could potentially have longer-term impacts on student success and STEM persistence.

First-generation and URM students in this study also faced more personal challenges during remote instruction, having less time to devote to school and greater difficulty balancing school with household responsibilities, a pattern that occurred regardless of major (Tables 4 and 5). Moreover, analysis of intersectionalities shows that of all first-generation students, URMs are the most negatively impacted (Table 6). Similarly, of all URM students, first-generation students were the most impact (Table 9). The challenges balancing school and home responsibilities likely stems from first-generation and URM students having significantly and substantially greater expectations with helping other household members with remote learning. In immigrant families, older siblings often serve as teachers or tutors for younger siblings (51) and frequently care for their siblings while parents are working (51–53), particularly in Latinx and first-generation households (54). These cultural expectations could explain why these students were more impacted by challenges in their remote learning environments than non-URM and continuing college students.

In total, 81% of our URM respondents were Latinx, a community that has suffered disproportionate economic impacts as a result COVID-19; during May 2020, the Pew Research Center reported the Latinx unemployment rate reached 18.9% compared to 14.2% for White workers (55). Given the correlation between first-generation and URM status among our respondents, it is unsurprising that these two demographics also showed similar signs of economic stress. These students were more financially secure prior to COVID-19 and were less likely to have financial resources to sustain their families through stay-at-home orders, a pattern seen broadly as well as in analysis of intersectionalities. These financial strains likely contribute to URM and first-generation students reporting that they had better access to healthy food on campus and lower access to food while at home engaged in remote instruction. Food insecurity is increasingly recognized as a problem on college campuses, particularly among minority students and those on financial aid (56), the latter which are more likely to be first-generation college students. Importantly, these food security issues are not just an issue of student health. Food insecurity lowers student academic performance and GPA (57), potentially compounding the inequities faced by URM and first-generation STEM students in higher education.

Importance of Student Perspectives in Survey Design

There is great interest in understanding how students responded to remote instruction imposed by COVID-19, and early studies include multi-campus student surveys (35, 36) to direct measures of student performance. UCLA also undertook several important survey efforts. First, UCLA participated in the University of California Undergraduate Experience Survey. Although designed to help understand students' academic and cocurricular experiences, the 2020 survey included questions about remote instruction. Results revealed student concerns around learning and social isolation, but did not specifically address potential differences among different identity groups. Moreover, while it did ask about technology challenges and student satisfaction with remote learning, with results similar to our survey, it did not explore how remote learning environments may impact student success. At UCLA, the Center for the Advancement of Teaching developed a survey included with standard course evaluations focused on providing data to inform instructors' future teaching preparation, especially with regards to making equity-minded choices to support all of our students. Students generally reported a positive experience with remote instruction, but noted challenges around lack of community. Like the UC-wide survey, these course-based surveys did not specifically explore how student identities might impact success in remote learning. A Fall quarter survey is planned to gain feedback from students concerning the evolution of remote teaching.

The above UC and UCLA surveys explored important topics needed to inform refinement of remote instruction, including issues surrounding synchronous and asynchronous course activities, grading methods, assessment practices, and social connection. Our study is unique, however, in that it was developed from a student's perspective, allowing us to move from simply asking if students struggle with remote learning to gaining insights into why they struggle. For instance, results indicate that difficulties in remote learning may result from specific challenges with home learning environments, providing insights into possible interventions. For example, URM and first-generation students have less time to devote to schoolwork, likely related to higher expectations for helping other household members with remote learning, creating difficulties balancing schoolwork with their household responsibilities. As such, one possible intervention could be a multilingual information campaign to educate parents on the challenges of remote learning, the time demands of college coursework, and how they can help their students succeed. Such interventions could be particularly impactful for first-generation students, whose parents have not experienced the challenges of college (58, 59). By tapping into unique perspectives of students in survey development, colleges and universities could gain a better understanding of their student populations, the origins of their challenges, and use this information to maximize student success.

Empowering students in a time of crisis

While our findings contribute to understanding inequities in remote learning in higher education, the process of developing this survey provides insight into novel approaches to authentic undergraduate research experiences, and how these pedagogies can support student success. As noted above, undergraduate research experiences have strong impacts on STEM persistence (60, 61), and CUREs are viewed as an important tool for engaging more students in research, increasing inclusion in STEM (15). Although COVID-19 forced the cancellation of in-person instruction, by focusing on the process of research inquiry, rather than specific bench or laboratory skills (e.g., analytical chemistry and microbial metagenomics), we successfully reenvisioned our field and lab-based research practicum for remote learning. This pedagogical shift provided an undergraduate research experience that had a strong positive impact on students during a time of crisis. Although the research was not as planned, student interviews show that the experience was meaningful and impactful.

Importantly, this experience empowered students during a uniquely difficult time by providing them a sense of agency. The UCLA Dean for Undergraduate Education, the Directors of AAP, PEERS, and the UCLA Center for the Advancement of Teaching program all supported the survey effort, showing the students a strong commitment by the UCLA administration. Moreover, by collaborating with the UCLA Center for Educational Assessment (CAT), the results of this student survey were directly conveyed to these critical stakeholders, with the Director of CAT and lead author presenting these results to every high-level committee at UCLA focused on remote instruction and maintaining continuity of teaching during COVID-19. Survey results are now part of a CAT resources webpage focused on successfully teaching through the pandemic. Through this experience, students learned that their research was valuable and could contribute to meaningful change.

Mitigating student challenges

Despite the many challenges faced by URM and first-generation students during remote learning, colleges and universities could improve their experience through policies and best practices that provide greater flexibility. For instance, while instructors could encourage class participation with "cameras on," it should not be required. Many students are living at home without quiet spaces to attend class, and may not have a working webcam. Similarly, synchronous class offerings should be avoided, if possible, or should offer sections with evening class times. Working an extra job to help with family finances and responsibilities and helping siblings with remote learning makes synchronous participation particularly challenging for URM and first-generation students. Moreover, many students have to share computers with siblings, and some reside in different time zones, making it difficult to attend synchronous classes. Similar flexibility with exam timing is necessary. Longer periods of time to take exams, or allowing timed exams to be taken at any point during the day would help students balance school with other home and/or work responsibilities, time zone differences, technology constraints, and would allow students to take the exam when they have access to a quiet space, helping students succeed. While many faculty voluntarily adopted such student-friendly policies, many did not, creating unnecessary difficulties, particularly for URM and first-generation students.

Remote learning hinges on technology. As such, universities should provide resources to improve student technology access. UCLA increased funding for grants and loans for student laptop purchase. In addition, through the UCLA library, students could borrow laptops and prepaid MiFi hotspots; the library even mailed equipment to students who were no longer on campus. While these actions undoubtedly helped reduce disparities in technology access, technology access problems persisted, suggesting a need to expand these efforts. Additionally, there were unexpected pitfalls. For example, all of the UCLA Library MiFi units were for a single carrier. As such, they worked well for students who lived in areas that received strong signals from that carrier, but not for students who did not, a problem that could be avoided by having contracts with more than one carrier.

Lastly, while there are tremendous financial strains on universities resulting from the pandemic, universities could greatly help students by being more supportive of student financial burdens exacerbated by the pandemic, where possible. For example, institutions could remove fees that are based on in-person student services that are no longer being provided. For example, UCLA charges students a fee for access to the campus recreation center despite students no longer having access to this facility due to the stay-at-home orders. Similarly, relaxing late fees for tuition payments would help students manage unexpected changes in their and their families' incomes. Given the increased food insecurity observed in URM and first-generation students, institutions could help organize relief efforts like the UCLA Community Program Office, that runs a food closet and also sends out grocery store gift cards to students facing food insecurity. Expanding these efforts and increasing outreach to inform students of these available resources could help mitigate student food insecurity.

CONCLUSION

Despite efforts to ensure equitable access to remote learning, our data indicates that first-generation and URM students face significant and often substantial disparities in remote learning. This result is not an indictment of institutional commitment; instead, it is a stark reminder of the challenges facing first-generation and URM students on college campuses (9, 22, 26, 28–30) and that remote learning can amplify these challenges. Further study is required to understand whether these results are unique to UCLA or to our particular sample of students, given the relatively low response rates resulting from survey fatigue. However, as universities continue COVID-related remote instruction , it is essential to understand how disparities in remote learning environments could impact vulnerable student groups, and work to mitigate those disparities to ensure equitable access to remote education.

Given that expansion of online learning is an important goal of many institutions (45), particularly as a way to decrease costs (62), it is important to continue to explore the advantages and disadvantages of each (63–65). Online instruction can offer many advantages for students (66, 67), providing students with greater access to courses, even from distant campuses, as well as greater scheduling flexibility. Indeed, many students in our survey indicated an increased interest in remote learning given their experience during the pandemic. However, this positive experience was not universal. While remote learning during COVID-19 may not be representative of remote learning broadly, as higher education expands the use of online instruction, it will be critical to address the obstacles that URM and first-generation students may face.

Critically, many of the insights from this study come from students using their unique perspectives to shed light on specific drivers of remote learning challenges. Although universities use surveys regularly to understand the student experience, we are unaware of any that include student voices in survey development as a standard practice. Doing so would not only provide unique and valuable insights into the student experience, but also provide novel research opportunities for undergraduate students that increase student engagement. Importantly, such research can be done completely remotely, potentially increasing access to undergraduate research.

The reenvisioning of a lab-intensive research practicum as an authentic undergraduate research experience—delivered completely online—and the strong positive impact of this experience on students, demonstrates that undergraduate research in STEM need not be limited to the lab or field. Although we did this research in response to COVID-19, this experience highlights an untapped opportunity to engage students in authentic research experiences remotely. Given that undergraduate research is strongly tied to STEM outcomes (60, 61), there is an increased need to provide access to undergraduate research. Although this class only included 20 students, the approach is completely scalable, providing a potential model for increasing access to undergraduate research experiences.

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