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COVID-19 is Not All Bad News: Negative and Surprisingly Positive Reports from College STEM Students and Implications for STEM Instruction

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Abstract

The negative educational consequences of COVID-19 are well documented. Much less investigated have been any potential positive outcomes of the pandemic. We surveyed 392 students at one college querying why they continue studying STEM or leave the STEM disciplines and about the effects of COVID-19 on their education. STEM students may have been especially impacted by pandemic-imposed remote instruction given STEM's reliance on hands-on laboratory experiences. Because the literature indicates that people of color and those from lower socioeconomic groups were more negatively affected by COVID-19, we hypothesized that students from these groups would report greater adverse educational consequences of the pandemic; however, this was not borne out by our findings. Across demographic groups, students reported negative impacts of COVID-19, although in a few areas we found that more traditionally "privileged" groups complained of more negative outcomes than traditionally "marginalized" students did. Most novel and dramatic in our results were the positive outcomes of the "lockdown" reported by students in the areas of enhanced resilience, improved social relationships, greater opportunities, academic improvement, and better mental health. We conclude with recommendations for addressing the negative outcomes of COVID-19 and remote instruction, and for taking advantage of the unexpected positive effects.

Introduction

Interest in the STEM (Science, Technology, Engineering, and Mathematics) field is flourishing, whether that be because of new career opportunities in technology or the spotlight on the sciences due to COVID-19's impact. This ever-growing interest calls for a broad array of perspectives which can be brought by people of diverse backgrounds, such as those who have been traditionally marginalized and recognized as minorities in the STEM disciplines (Science benefits from diversity, 2018). However, according to national data, despite PEER (Persons Excluded due to Ethnicity or Race; Asai, 2020a) and first-generation college students' interest in pursuing STEM being equivalent to that of their White (non-PEER) and continuing generation counterparts, these students are less likely to graduate with STEM degrees (Witham et al., 2015). In addition, women are also underrepresented in STEM majors (Rainey et al., 2018).

Perhaps this underrepresentation of certain student groups could be due to the non-inclusive STEM environment. PEER students often report feeling that they "don't belong" in STEM classrooms and majors (e.g., Palmer et al., 2011; Rainey et al., 2018; Strayhorn, 2012, 2015). Many aspects of the *individual* contribute to this, among them variations in students' science identity (Hazari et al., 2012), high school preparation (Palmer et al, 2011; Xie et al., 2013), and academic self-confidence (Moakler & Kim, 2014). However, larger *structural* factors can also deter students from equal participation in STEM. For example, PEER students note that STEM course content and pedagogy, including more lecturing in STEM than in other disciplines (Eagan, 2016), seem to exclude them (Chesler, 1997; Xie et al., 2015). Our own focus group and survey research with PEER, international, and first-generation college students identifies other contributors to this feeling of alienation, including intimidating stereotypes regarding STEM, instructor assumptions, and unwelcoming peer behaviors (Propsom et al., 2019). STEM students identifying as women also feel less supported and less comfortable in STEM classrooms (De

Grandi et al., 2021) and this is compounded for PEER women in STEM (Malone & Barabino, 2009; Rainey et al., 2018).

One group often overlooked in discussions regarding STEM inclusion is Asian American students, perhaps because they are well-represented in the STEM field and are viewed as the "model minority" (McGee et al., 2017). However, these groups have been and continue to be vulnerable to racist hate crimes, with South Asian and Middle Eastern individuals facing prejudice due to post-9/11 harmful stereotypes, and East and Southeast Asians impacted by COVID-19 misinformation and fear-mongering (Mittelmeier & Cockayne, 2020). Rainey et al. (2018) found that although Asian American students may persist in STEM majors, they report a lower sense of belonging, more similar to that of PEER than White students.

The existing pandemic of racism has been compounded by the pandemic of COVID-19 (Asai, 2020b). Not only has COVID-19 contributed to over 6 million deaths worldwide (World Health Organization, 2022), it has caused economic, social, and scientific disruption, with these burdens falling more heavily on communities of color (Tai et al., 2021). In terms of social disruption, within the same year that COVID-19 hit the United States, Black Lives Matter and civil rights protests amplified as an impassioned reaction to the tragic murders of numerous innocent Black individuals by police brutality (Taylor, 2021).

Disruptions due to COVID-19 have challenged the education system in ways it never has been before, especially impacting PEER and low-income students, and in turn radically affecting how young people will adapt to their adult lives and careers. Some students have had to balance their education with jobs and helping their families, and some have had to self-isolate away from family members to resume their education (Kuhfeld et al., 2020). Many educational institutions across the globe shifted from face-to-face to online instruction (Tasso et al., 2021). Students reported accompanying complications, such as an increased coursework, uncomfortable

surveillance methods intended to prevent cheating, and pre-recorded lectures with a lack of student-professor communication (Pagoto et al., 2021). Means and Neisler (2020) conducted a national survey of college students during COVID-19 and found that students' most significant self-reported challenges had to do with lack of motivation and hands-on experiences, and that these problems were greater for Hispanic and lower income students. Gupta et al. (2021) conducted surveys and interviews of primarily PEER students in STEM at two points in the pandemic and indicated that these college students reported missed opportunities, isolation, and lack of access to mental health resources. First-generation college students were also hit especially hard.

These negative repercussions of the pandemic have been well documented, and although it might be hard to imagine that positive outcomes could have resulted, Tasso et al. (2021) found that students surveyed during the pandemic reported not only fears and academic frustrations due to COVID-19, but also fairly high ratings on happiness and enjoying life. It is possible that the "pause" and isolation caused by the pandemic might have allowed college students the time and space to reflect on their career aspirations and prioritize what matters to them, including family, activism, and self-care.

The purpose of the present study was to investigate why students persist in or leave STEM and evaluate how COVID-19 impacted college STEM students' academic experiences, motivations, and career aspirations. Because much research has already identified the negative impacts of COVID-19, we sought to inquire about any potential positive outcomes. We studied this by developing a survey shared with the entire student body at one midwestern liberal arts college. We anticipated that pre-existing disparities between more privileged students (e.g., White, men, and continuing-generation college students) and those from traditionally marginalized groups might have expanded during the pandemic. We also sought to investigate

the pandemic's impact on international students, many of whom not only took classes remotely while in their home countries but often attended these synchronous courses in the middle of the night because of time zone differences. The hope was that identifying the self-reported effects of the pandemic might allow faculty and higher education institutions to take steps to remediate potential negative effects and build on any positive outcomes.

Method

Participants

A total of 392 students (24% of the student body) from a midwestern liberal arts college responded to the survey. Of the respondents, 323 completed the final question of the survey. Women (64%) were overrepresented compared to men (32%); the remainder of the respondents (4%) selected a gender identity other than male or female or preferred not to disclose their gender. The majority of the respondents were domestic students (77%) and 69 were international students (21%). Seventeen respondents were African American or Black (6%), 25 Asian American (8%), 24 Latinx/Hispanic (8%), and 108 White (61%). According to demographic information provided by the university's Office of Institutional Research, the sample fairly accurately reflected the school's student population demographics; however, there was a slight overrepresentation of international students and Asian American students compared to their numbers in the student body (17% and 3%, respectively).

Materials

The survey consisted of 21 questions, including 18 closed-ended and 3 open-ended questions. We asked whether or not students were STEM majors and if they had ever considered majoring in the STEM field. Two questions addressed why interested students had left STEM; many of the response options were taken from a survey study on gender differences in STEM pathways by Maltese and Cooper (2017). One question inquired into what kept STEM majors in

the STEM disciplines, providing 12 response options: *interest/passion for the field, interesting classes, professors/staff members who care about me as a person, influence of family, pursuit of career opportunities, the relationships I have built with people in STEM, volunteer/work experiences, research experiences, desire to help people, feeling of belonging in STEM, perceived financial security of STEM careers,* and an open-ended response in which students could explain a reason not mentioned.

In another section we asked students if they had taken remote STEM courses during the pandemic and, if so, to what extent COVID-19 impacted a variety of outcomes such as grades, interest in STEM, learning in STEM courses, quality of STEM courses, and their ability to obtain in-person and hands-on experiences such as labs and internships. Response options were on a 5-point scale, ranging from *a large negative impact* (1) to *a large positive impact* (5). We inquired into whether remote STEM courses led students to feel more or less prepared for other STEM courses, internships, graduate/medical school, and careers, with response options also on a 5-point scale. Students could indicate from a variety of categories the ways in which COVID-19 continues to impact them.

Because we had provided ample space for students to express their negative experiences as a result of COVID-19, we explicitly asked an open-ended question about whether the pandemic impacted them positively in any way. The final five survey items were demographic questions.

Procedure

We recruited students for our survey through an email sent by the university registrar's office to all enrolled students. To create and distribute the survey, the online software Qualtrics was used. Participation was voluntary and anonymous, and survey completion took 15 minutes

or less. To incentivize participation, students had the ability to opt into a lottery to win one of 10 $20 Amazon gift cards. The survey was administered online from Feb. 14 - 25, 2022.

Results

STEM majors at our institution include eight departments: Biology, Chemistry & Biochemistry, Computer Science, Geoscience, Kinesiology, Mathematics, Physics & Astronomy, and Psychology & Neuroscience. STEM majors were overrepresented in the sample, likely given the survey's focus on STEM. Although only about one-third of the degrees awarded at our institution are in STEM fields, self-identified STEM majors made up 52% of the sample.

Of those who responded to the question about whether they entered college intending to be a STEM major, 48% answered affirmatively. When asked, "As a STEM major, what keeps you in STEM?" (to which they were instructed to check all responses that applied), the most frequent responses were interest/passion for the field (84% of all STEM major respondents), pursuit of career opportunities (72%), and interesting classes (64%). The least common selection was "The relationships I have built with people in STEM," at 19%.

In response to the question, "If you are no longer a STEM major or declared a major other than STEM, why? (check all that apply)," the most common among the 175 responses for this question (reported as frequency and percentage of all responses given) were that they found their passion elsewhere (n=36 or 21% of all responses), they were more successful in other courses (n=29, 17%), content in other disciplines was more interesting or relevant (n=24, 14%), and that they lost their passion for STEM (n=20, 11%). We then asked if students had ever felt "pushed away" from STEM and of the 83 students who answered this question, 34 responded affirmatively. The reasons most frequently indicated for feeling pushed away included STEM courses being poorly taught (18 responses), and not getting the grades they wanted or needed, not liking the competitive culture, and concerns about work/life balance–the latter three reasons

all garnering 16 responses. A gender analysis found that those feeling pushed away from STEM were significantly more likely to identify as women (85%) than men (15%), $X^2(1)=5.03$, $p=.02$.

Among the 323 completed surveys, 81% of participants reported taking remote STEM courses during the pandemic. In response to the closed-ended question regarding the effects of COVID-19, findings indicated that some domains were relatively unaffected, some showed divided responses on whether effects were positive or negative, and others yielded predominantly negative effects. We classified a "net neutral" effect when the most common response was "no impact" or when the number reporting a negative effect was similar to the number of respondents reporting a positive effect. Net neutral effects were found on grades, STEM passion, success in STEM courses, and the ability to enroll in STEM courses. In contrast, all other categories resulted in a majority of negative reports. We combined the response options of *large negative impact* and *slight negative impact* to determine negative outcomes for remote STEM courses and found adverse consequences for learning in STEM courses (62%), quality of STEM courses (62%), ability to get in-class and in-person lab experiences (64%), ability to get internships or research experiences (58%), and opportunity to get volunteer or shadowing experiences (53%).

In response to the question, "Do you feel like remote STEM courses helped you to be more prepared or less prepared for the following…," a majority of students reported large or slight negative impacts on their preparation for other STEM courses (56%), internship experiences (54%), and job/career (52%). Although one-third of students felt no effect of remote STEM courses on their preparation for graduate or medical school, a near majority (48%) indicated feeling less prepared.

Another question inquired about the *continuing* impact of COVID-19 on students, asking them to check all response options that applied. As is shown in Figure 1, effects were many and

varied, impacting both students' personal lives and academics (note that students could check multiple responses). The most common *continuing* effects were on missed experiences/opportunities, motivation/focus, mental health, and loneliness and isolation.

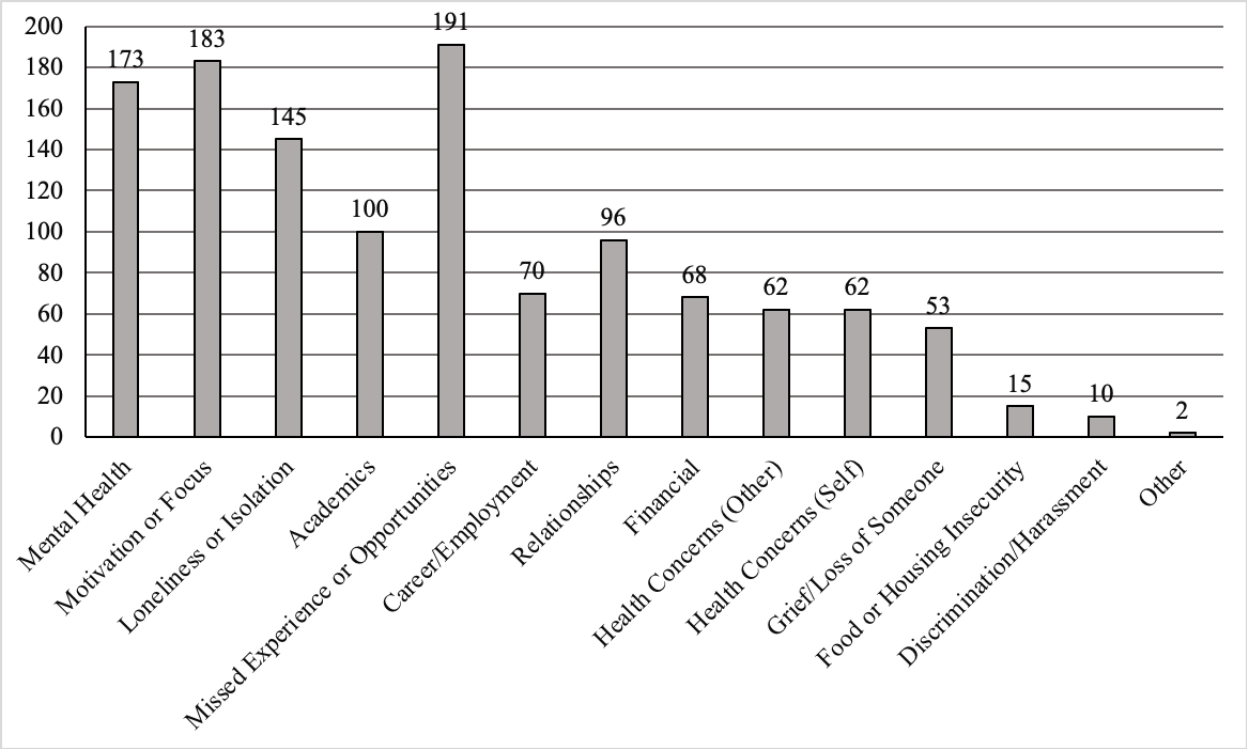

Figure 1. Frequency of student responses to the question, "In which of the following ways, if any, has COVID ***continued*** to impact you?" Note that respondents could select multiple answers.

In addition, we also asked two open-ended questions, one of them more general, eliciting further comments about how COVID-19 may have affected students' STEM major plans and experiences, and the other more focused, explicitly inquiring about whether the pandemic impacted them positively in any way. To analyze the open-ended questions, we categorized responses by having multiple researchers read the responses and individually identify themes. Next, all researchers shared their themes and we created common categories with sample quotations to illustrate them. Tables 1 and 2 present the recurring negative and positive themes, respectively, listed in order of frequency. The most common negative themes were lack of

hands-on experience, bad academic experiences, interrupted schedule, and lowered efficiency/focus/motivation. In response to the question about positive outcomes, students identified gains in what we called "mindset" or resilience, improved social relationships, greater opportunities, academic improvement, and better mental health.

Negative Theme Categories	**Illustrative Quotations**
Lack of hands-on experiences	*"COVID definitely limited my lab skill abilities for future classes and for future research/internship opportunities and I don't feel I got as great as an education through online classes during this time."*
Bad academic experiences (e.g., grades, reduced learning)	*"As someone with ADHD, my performance suffered, and I wasn't able to get the grades I usually obtained in my previous years as a student."* *"Classes got easier so my GPA went up, but that is kind of bad because I was learning less than I could have in person."*
Interrupted schedule	*"Because of COVID, I felt I had lost out on in-lab technical experience I wanted for my future career, and I missed out on study-abroad opportunities I was really looking forward to because of cancellation due to the virus."*
Low efficiency/focus/motivation	*"I think COVID made it more difficult to pay attention for more strenuous STEM courses, as I was feeling more and more burnt out as well as increasingly behind on my work."*

Table 1. Categorized negative themes contained in students' open-ended responses regarding COVID's effects on them, listed in order of frequency.

Positive Theme Categories	**Illustrative Quotations**
Mindset/resilience	*"Gave me resilience and gave me greater problem solving tactics."* *"Academically it taught me to be flexible and learn how to teach myself, therefore allowing me to discover the learning strategies that worked for me."*
Improved social effects/ relationships	*"I think it has impacted me positively by forcing me to address some problems with my family that I would not have if I had studied abroad. It also allowed me to get more experience in my health field because I didn't study abroad."* *"I feel that the pandemic has helped me build some new relationships. With being home most of the time when school was taught remotely I learned to reach out to more people virtually via text, calls, zoom etc. It helped in trying not to be so lonely."*
Greater opportunities	*"It created more computer science and IT jobs because computer use in the workplace has skyrocketed."* *"I utilized this instability as a pause and moment to reflect on what it is I desire out of my education, career, relationships, and life. It was a fleeting moment as most 'pauses' are."*
Academic improvement	*"I think it helped me learn as I was able to rewatch lectures."* *"COVID allowed me to take two courses in the exact same time bank due to my ability to work on them asynchronously as necessary. This allowed me to clear a major hurdle in the pursuit of this double major that I may have struggled to overcome otherwise."*
Better mental health	*"Isolation offered me a lot of opportunities for introspection and I feel better about myself than ever. Also masks just make me less self conscious."* *"I have been able to allocate more time to other things since my classes were virtual, such as hobbies and was also able to start getting therapy during COVID."*

Table 2. Categorized positive themes contained in students' open-ended responses regarding COVID's effects on them, listed in order of frequency.

To examine our hypothesis that there might be disparities in effects by demographic groups, the questions that had scaled response options were analyzed using a series of independent t-tests. For example, we compared first-generation versus continuing generation student responses with regard to COVID-19's impact on grades, quality of STEM courses, preparation for other STEM courses, etcetera, and found no significant differences on any of the items. A similar lack of difference on most of these items was found for PEER vs. White students. There was, however, a marginally significant difference on "learning in STEM courses" with White students reporting a more negative impact (M_W=2.16, SD_W=1.06) than PEER students (M_P=2.47, SD_P=1.00), $t(136)=1.76$, $p=.08$. There was also a marginally significant effect on reports of the quality of their STEM courses, $t(137)=1.95$, $p=.053$, again, with White students reporting a more negative effect (M_W=2.06, SD_W=.87) than PEER students (M_P=2.39, SD_P=1.10).

These questions were then analyzed by international versus domestic student status. Domestic students (M_D=2.87, SD_D=1.06) reported significantly less success in their STEM courses taken during COVID-19 than did international students (M_I=3.21, SD_I=0.97,), $t(232)=2.20$, $p=.03$. Similarly, domestic students' ratings of their learning (M_D=2.17, SD_D=0.97) and the quality of their STEM courses (M_D=2.09, SD_D=0.88) were significantly lower than those of their international peers (M_I=2.74, SD_I=0.98; $t(234)=3.92$, $p<.01$, and M_I=2.62, SD_I=1.10, $t(234)=3.832$, $p<.01$, respectively). For other items, there were no significant differences found.

Discussion

The purpose of this study was to examine why college students stay in or leave STEM, investigate the impacts of COVID-19 and remote instruction on STEM students, and discover whether there were disparate effects by demographic groups. Consistent with the work of others (e.g., Maltese & Cooper, 2017), the main reason students gave for persisting in STEM was their

passion for the field. Similarly, the primary rationale given for leaving STEM or choosing a different major was finding their passion elsewhere. One of the explanations that our respondents who were initially interested in STEM gave for leaving the field is that STEM courses were poorly taught. Eagan (2016) found that STEM classes, more so than those in the humanities and social sciences, are likely to use lecturing rather than student-centered pedagogies. Some of our respondents also reported leaving STEM because they didn't get the grades they wanted or needed, which is consistent with a common stereotype that STEM disciplines utilize courses as "weed-outs." Witteveen and Attewell (2020) found there is an actual "STEM-grading penalty;" by examining the same students across different courses, they demonstrated that students receive lower grades in their STEM courses than in those taken in other disciplines. Although we found few demographic differences in our analyses, results did indicate women were more likely to report feeling pushed away from STEM than men, which is of concern. Maltese and Cooper (2017) discovered that women's persistence in STEM is influenced by the support of others to a greater extent than is men's STEM persistence, suggesting that STEM faculty, staff, and parents should be attentive to this factor so that we can retain diverse and valuable talent in STEM.

Similar to results garnered from national surveys (e.g., Gupta et al., 2021), our findings indicated many negative academic impacts of COVID-19 and remote instruction on STEM students. Students reported adverse effects on the quality of their courses and learning, lack of ability to obtain valuable hands-on experiences in labs and internships, and feelings of poor preparation for future STEM courses and professional opportunities. One student quotation from our study illustrates this: "It was difficult to find opportunities to work or shadow because in many medical fields during the pandemic outside visitors or non-essential personnel was not allowed. I also was unable to practice the use of key equipment in XXX labs that I am now

having to learn to use for my senior thesis." This lack of hands-on experiences in internships and labs has been frequently cited in other research as well (Dickson-Karn, 2020; Franchi, 2020).

Not only were students' academic lives disrupted by COVID-19 and remote instruction, but their social and emotional lives suffered as well. As reported by Gupta et al. (2021), students experienced mental health and motivational challenges due to isolation, which was confirmed by Wester et al. (2021) and our own results.

Still, what has been largely neglected have been the potential positive impacts of the pandemic and remote instruction. A few researchers have shed light on this area, but they have been in the minority. Although Tasso et al. (2021) focused on the pandemic's negative emotional consequences for students, they also found some fairly positive ratings (above the midpoint) on the emotions of "happiness" and "enjoying life." Desrochers et al. (2020) found that students remained optimistic about their future careers despite the pandemic. Because many others have already reported on the numerous adverse effects, we chose to explicitly inquire about potential positive outcomes. This is not to argue that COVID-19 was an overall good phenomenon– we acknowledge the severe negative impacts this pandemic has had on people globally. Rather, we sought to determine if the switch to a more remote and asynchronous lifestyle had benefits, and from our results, they clearly did have some sort of a positive impact. In fact, students wrote extensively about their positive experiences or perceptions, often quite poignantly. For example, one respondent wrote, "I think the pandemic was a blessing in disguise for me. I believed it provided time for me to be by myself and truly focus on my mental health and water some of my passions, such as baking, learning a foreign language, and meditation, I had not had the most time for previously. More importantly, it brought me closer to my family and sister, something that I will forever be grateful for, and know that when I am older, I will greatly appreciate that."

Although our survey respondents reported missed opportunities as a negative consequence of the pandemic, on the positive side, some noted *new* opportunities, for example, with respect to jobs. They also reported having time to attend to mental health issues, develop better social relationships, improve their academics, and build resilience. Whether these self-reports are accurate or merely positive reinterpretations may not matter. As psychology shows, perception is often reality and when people can positively reframe stressful events they can experience enhanced psychological benefits (e.g., Folkman, 1997). Our results add greater nuance to previous findings of primarily negative outcomes of the pandemic and remote instruction.

Regarding the issue of potential disparities by student demographics, we were surprised to find few differences by demographic groups overall, given that past research has demonstrated biased treatment of and unequal outcomes for PEER and women students in STEM (e.g., Malone & Barabino, 2009; Strayhorn, 2012; Witham et al, 2015). For example, Riegel-Crumb et al. (2019) found that Black and Latinx students switch out of STEM at higher rates than from other disciplines, and therefore we expected that PEER students might report being even more severely impacted by the pandemic and remote STEM instruction than other students. We found that students' overall reported their STEM major experiences were negatively influenced by the COVID-19 pandemic, regardless of their demographic groups, with two exceptions. First, White students reported marginally more negative impacts of COVID-19 on the quality of their STEM courses and their learning in STEM classes compared to PEER students. Second, compared to international students, domestic students reported significantly more negative impacts of COVID-19, including lower learning and less success in their STEM courses, and lower quality of the courses. A similar, although non-significant effect, was found by gender, with men reporting more negative outcomes than women. One possible interpretation of these results is

that privileged students (i.e., White, domestic, and male students) are not as used to having to adapt whereas international, PEER, and women students have more experience responding to challenges and may therefore have developed greater resiliency, leading the latter groups to cope more effectively with the hardships of COVID-19 and remote instruction or to complain less about it. Another potential reason for these students complaining less about their struggles could be due to imposter syndrome (Schmaling et al., 2017). If an individual already feels that they do not belong in an environment, they are less likely to complain about it.

Conclusion

We believe that the primary contribution of our research is identifying the many positive consequences of the pandemic and remote instruction reported by students. The open-ended nature of some of our questions allowed for students to share their lived experiences in their own words. Additionally, because the survey was anonymous, students might have felt comfortable reporting honestly on sensitive and vulnerable topics such as mental health.

There are several limitations to this study as well. The main weakness is that the survey was conducted at only one small liberal arts college and not all participants who started the questionnaire completed it, both of which likely reduce the generalizability of the results. Additionally, representation of PEER and non-STEM students was fairly low, limiting conclusions regarding these students' experiences. Participation of LGBTQ+ individuals, students with disabilities, and those from lower economic backgrounds is unknown, and exploring barriers and contributors to their STEM success might yield helpful insights. Another limitation is the survey methodology itself, which assumes that participants can accurately and honestly report on their experiences, which may not always be the case. Because we explicitly asked students about positive consequences of COVID-19, they might have felt pressured to identify some, which may have inflated the reports of benefits.

Recommendations

COVID-19 is not over; it is an ongoing process and students are still experiencing its effects. Our results lead us to pose several recommendations for universities and STEM course instructors.

1. Address student mental health issues. Given the feedback from our respondents and those from national surveys (e.g., Gupta et al., 2021) regarding mental health challenges, it is increasingly important that colleges and universities provide adequate mental health services and support that are accessible to all students. Gupta et al. (2021) suggested dedicating course time to raising awareness of this issue, and we concur; possibly inviting someone from university counseling services to give a brief presentation or at least orienting students to the resources available would normalize seeking help, something that could be especially beneficial to students who have been raised in environments where discussion of mental health is stigmatized.
2. Provide "hands-on" make-up opportunities for students. In order to minimize the detrimental effects of COVID-19 and remote instruction on STEM students' academic and career opportunities, universities could provide more hands-on opportunities in an attempt to make up for experiences students missed during the pandemic. Incorporating more practice with lab skills, offering supplemental workshops, and providing or at least better advertising internship and research opportunities could help students compensate for what they missed.
3. Improve STEM instruction. There were calls for STEM instruction reform even before the pandemic mandated a change in teaching practices. Evidence suggests more active-learning techniques (Freeman et al., 2014) and highly structured classes (Haak et al., 2011) yield learning gains in STEM courses, especially for PEER and economically

disadvantaged students. The utilization of different instructional techniques during COVID-19 provided students with alternative opportunities to comprehend class materials. Some instructors moved to more of a "flipped classroom" format as a way to engage students and utilize technology. Boevé et al. (2017) suggested that this style of teaching enhances students' understanding of class materials, at the same time keeping them engaged. Many teaching colleagues reported reducing content during the pandemic (Lederman, 2020). Although this was an emergency adaptation, it is consistent with recent pedagogical changes focused on stressing "core ideas" and depth (e.g., Cooper et al., 2017) rather than breadth and trying to "cover everything" (Petersen et al., 2020). STEM faculty members should utilize the feedback from students and their own personal reflections regarding what instructional techniques worked and what didn't work during remote instruction as they revise their courses and pedagogies moving forward.

4. Incorporate more opportunities and spaces for reflection. Even prior to COVID-19 there were concerns that many college students were "overextended and overcommitted" (Mintz, 2019). Our results indicate that some students appreciated the "pause" provided by the pandemic. Perhaps instructors could create these breaks in class or add brief exercises to encourage reflection. Cohen et al. (2006) demonstrated that a 15-minute writing assignment affirming students' personal values increased African American students' grades by reducing stereotype threat. Follow-up research demonstrated that a similar self-affirmation intervention worked to reduce student stress (Sherman et al., 2009). These breaks would no doubt prove beneficial for instructors as well.
5. Address diversity, equity, and inclusion in STEM. Although our study found few significant differences between PEER students and their more privileged counterparts during the pandemic (which could be due to the small number of PEER students who

responded to our survey), others (e.g., Gupta et al, 2021; Means & Neisler, 2020) demonstrated that PEER and lower income students experienced more educational challenges during the pandemic. Given the vast literature demonstrating inequities in STEM education and outcomes for PEER and first-generation students *prior* to the pandemic (e.g., Witham et al., 2015), we advocate for addressing these continuing issues and integrating diversity, equity, and inclusion more fully into STEM courses. If STEM is to flourish, we cannot afford to lose the talent of any potential contributors and our field can only benefit from a greater diversity of perspectives.

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