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Student Engagement Declines in STEM Undergraduates during COVID-19–Driven Remote Learning†

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We examined how the shift in learning environment from in-person to online classes, due to the COVID-19 pandemic, impacted three constructs of student engagement: behavioral engagement, including students' frequency of participating in class discussions, meeting with instructors, and studying with peers outside of class; cognitive engagement, including students' sense of belonging and self-efficacy; and emotional engagement, including students' attitudes toward science, their perceived value of the course, and their stress. Seventy-three undergraduate STEM students from across the country completed five-point Likert-style surveys in these areas of student engagement, both prior to their science course transitioning online and at the end of the spring 2020 semester. We found that while overall behavioral engagement did not change, students participated less frequently in class discussions but met with professors more often outside of class. We saw no significant change in cognitive engagement, indicating that while students' sense of belonging and self-efficacy ideally increases over the course of the semester, in this case, it did not. Most alarmingly, we found a significant decrease in emotional engagement, with students reporting a drastic decline in positive attitudes toward science. Students' reported stress levels remained unchanged, and students reported a slight increase in their perceived value of the science course they were taking. These data shed light on how the transition to online learning had an overall negative impact on undergraduate student engagement in science courses.

INTRODUCTION

Due to the outbreak of COVID-19, schools across the world stopped in-person classes and switched to remote, online instruction in early spring 2020. The geographic scale and speed at which these transitions occurred were unprecedented, and the COVID-19 disruption to education will likely have long-term effects on higher education (1). In the United States, the first COVID-19 cases were reported on college campuses in mid-February 2020, but because of a dearth of both useful guidelines and preexisting models designed to address such crises, it took almost a month for most colleges to implement widespread campus closures. To transition online, many institutions extended their spring semester break, while others provided only a couple of days to allow faculty time to prepare for online teaching; eventually, the universities publicly announced that in-person classes would not resume for the rest of the semester (2). This rapid transition was especially problematic because the majority of faculty at 4-year institutions had no previous experience teaching online (Walsh, Arango-Caro, Wester, and Callis-Duehl, submitted for publication). Under these conditions, many faculty struggled to keep their students engaged in learning while implementing effective practices that would allow them to make full and proper use of the unique nature of online teaching (3; Walsh et al., submitted).

The students themselves also faced a myriad of personal and academic challenges during and after the transition from in-person to remote learning. With campus dormitories shuttered alongside the academic buildings, college and university students were tasked with maintaining their academic pursuits while simultaneously dealing with the problems involved in moving off campus during a global pandemic (4). Students who lived on campus when their university transitioned to remote learning therefore suffered a disproportionate negative impact from the shift to remote learning. This example brings into sharp focus the importance of equity and inclusion when considering the impact of non-academic aspects of educational disruptions (5). The

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requirement to move off campus with little notice created an acute challenge for those who had no convenient place to go at a moment's notice. Even students able to return to their childhood homes often faced crowded and noisy workspaces, with other family members engaging in their own activities under the same roof (6). More disruptively, some domestic students did not have a family home to return to, or could not afford to return home, while many international students were left stranded in the United States, with few options and little recourse (7, 8). For other students, the financial strain of returning home meant taking on new employment to support themselves and, in some cases, their family (4). Thus, the switch to online learning likely exacerbated pre-existing academic and financial inequality amongst students (9). We predicted that these abrupt and drastic changes would decrease student emotional and behavioral engagement in spring 2020 courses.

In the wake of COVID-19, researchers made concerted efforts to capture student responses to this educational disruption and understand its impact on learning in order to design and formulate recommendations for the future (3). As a result of this concerted research, evidence of academic student difficulties emerged. For instance, multiple studies found that students in chemistry courses struggled with staying motivated and engaged after the transition to online learning (5, 10). In a survey of one lecture-based course, the students who participated in optional active learning activities in person were different from those who participated after the transition to remote learning (11). STEM students from multiple disciplines shared that they were concerned about losing hands-on experience in practical laboratories (12, 13). The loss of in-person classes made the adjustment to online teaching especially difficult in STEM courses because hands-on experiences and inquiry in practice-based labs foster student learning and applied skills (13). Capturing baseline data along with real-time student data on the impact of COVID-19–related shifts in the education environment is essential to improving our understanding of how education during emergencies impacts student engagement in STEM.

Student engagement is a multidimensional construct, partitioned into three categories: behavioral, cognitive, and emotional (14). Behavioral engagement refers to the student's participation in academic or social activities; cognitive engagement is defined by a student's ability to comprehend new ideas and master intellectually challenging skills; and emotional engagement includes emotional reactions, both positive and negative, to peers, instructors, and self.

We hypothesized student engagement would decline under the stressors brought about by the COVID-19 pandemic as students were forced to deal with unprecedented shifts in academic and social environments. To model student engagement, we assessed several constructs within the three individual categories of engagement previously described. Behavioral parameters included frequency of active participation in class, meeting with instructors outside of class, and meeting with study groups outside of class. We used student affect, consisting of self-efficacy and sense of belonging, to assess a student's cognitive engagement with class material. Finally, the analysis of emotional parameter constructs centered primarily on the student's value of the course, stress level, and attitude.

To evaluate behavioral engagement, we selected three self-reportable behaviors typically correlated with academic success: (i) participating in class, (ii) talking with instructors outside of class, and (iii) studying with peers outside of class. Class participation improves a student's critical thinking skills, increases motivation, and leads to higher course grades (15). Interacting with an instructor outside of class (e.g., office hours, e-mail) positively impacts a student's grade and level of academic engagement (16, 17). Developing bonds with peers and using study groups are positively correlated with academic performance and improve a student's likelihood of remaining in STEM (18, 19).

The student affective learning theory (20) states that affective learning connects feelings that arise during the educational process with the progression of the learning itself (21). According to Trujillo and Tanner (21), there are three main constructs within affective learning: (i) self-efficacy—how a person acquires beliefs about their ability to do something; (ii) sense of belonging—acquiring a feeling of being part of a community; and (iii) science identity—seeing oneself as a scientist. In this study, we used student affect to evaluate the cognitive component of student engagement. However, the third construct, student identity, takes years to build (21), and therefore was not included in this analysis due to the focus on the short-term, acute changes during the pandemic.

Self-efficacy is an aspect of social cognitive theory defined as the belief you have in your ability to do something correctly (22). Sources of self-efficacy include direct experience, vicarious experience, healthy emotional/physiological states, and social persuasion. Social persuasion and social learning, for instance, can increase self-efficacy on the principle that students who are surrounded by their peers and feel supported are more likely to sustain efficacy (21, 22). In the case of COVID-19, students may have moved from supportive peer environments to social isolation, potentially reducing their self-efficacy. Additionally, students assess their success by the feelings they experienced doing a task; thus, their perceived success can subsequently influence their ability to accomplish the task again (23, 24), but it is not clear whether these feelings of success during in-person learning translate to the same feelings in an online environment, potentially impacting their self-efficacy.

A sense of belonging relates to a human need to belong to a group (25) and is known to positively influence student motivation, achievement, and overall well-being (26). Previous studies have found that engagement with fellow students outside of the classroom learning environment increased sense of belonging and that persistence in a program can be positively correlated with peer group connections, student-faculty interaction, self-efficacy, and

TABLE 1.
Overview of surveys and questions administered using the Qualtrics survey system.[a]

Engagement Construct	Student Parameter Measured	Survey or Question Used	Number of Questions	Format	Example Question
Behavior	Meetings with professor	"How often did you meet with professors outside of class time?	1	5-point Likert Scale: 0 = Never, 1 = Once a semester, 2 = 1–2 times a month, 3 = Once a week, 4 = More than once a week	See Questions Used
	Participation in class	"How often did you participate in class discussions?"	1		
	Study group	"How often did you study with other students outside of class time?"	1		
Cognitive	Self-Efficacy	General Self-efficacy Scale (GSE) (43)	10	5-point Likert Scale: 1 = Strongly disagree, 2 = Somewhat disagree, 3 = Neither agree nor disagree, 4 = Somewhat agree, 5 = Strongly agree	"I can solve most problems if I invest the necessary effort."
	Sense of Belonging	Ingram Sense of Belonging survey (44)	20		"I would find it easy to join study groups with other students if I wanted to."
Emotional	Attitude	Colorado Learning Attitudes about Science (CLASS) (45)	14		"I think about the science I experience in everyday life."
	Value	Papanastasiou survey (46)	8		"The skills I have acquired in this class will be helpful to me in the future."
	Stress	Papanastasiou survey (46)	8		"This class is stressful."

[a] All surveys were combined into one for ease of student participation.

overall achievement (21, 27–31). Previous studies have also suggested that students who leave college often do so due to a lack of social integration that causes them to suffer from a diminished sense of belonging (21, 30, 32). Sense of belonging is an important construct to measure for this study because, as students dealt with the abrupt change in their learning environments, they lost many of the aspects of the learning experience that could potentially positively influence their sense of belonging.

Emotional engagement is quantified here in terms of attitude and anxiety, the latter consisting of value and stress. Student attitudes toward science and science classes correlate with student persistence in the course and subject. Students' attitudes toward biology include four latent constructs, beyond content and structure of the discipline: personal interest in the subject, the connection a student feels the subject has to real-world issues, and problem-solving synthesis and problem-solving effort (33). These constructs can be combined for an overall "attitude toward science/biology" that indicates how closely a student's views of science align with expert views. One of the most important influences on student attitude toward a course is the method of delivery of information, or modality, for example, in-person versus online learning (34–37). Because the way in which science is taught often shapes how students perceive science (33), we predict there will be a negative shift in students' attitudes due to the mid-semester shift in the learning environment in spring 2020.

Student anxiety can be triggered by a variety of educational experiences and varies between learning environments, thus impacting student perceived value of the course itself (15). Psychiatric experts predict a rise in anxiety and stress due to the COVID-19 pandemic (38), and preliminary data out of China reveal students are more likely to experience negative emotions due to the pandemic (39). Since increased anxiety is known to correlate with decreased persistence and performance in class (40–42), we predict that the stress students faced due to shifts in academic and social environments related to COVID-19 will negatively impact student engagement in science courses.

METHODS

As universities announced their closures and timelines for moving their in-person classes online, we quickly identi-

TABLE 2.
Survey measurements[a] collected from 73 biology students at the beginning of the transition online due to COVID-19 and at the end of the semester.

Engagement Construct	Student Measurements	Pre-COVID-19 Transition	Post-COVID-19 Transition	Matched Pairs *t*-test *p*
	Single Likert measurements			
Behavior	Class participation	3.2 ± 0.1	2.9 ± 0.1	0.006
Behavior	Met with professor	1.6 ± 0.1	1.8 ± 0.1	0.036
Behavior	Met with peers	2.3 ± 0.2	2.2 ± 0.1	0.437
	Calculated measurements			
Cognitive	Self-efficacy	35.0 ± 0.6	34.8 ± 0.7	0.700
Cognitive	Sense of belonging	35.4 ± 1.1	34.6 ± 1.1	0.240
Emotional	Attitude toward science	9.4 ± 0.8	3.5 ± 0.5	< 0.001
Emotional	Value	30.4 ± 0.8	31.6 ± 0.7	0.056
Emotional	Stress	4.3 ± 1.3	5.7 ± 1.2	0.669

[a] Measurements include a composite of multiple survey responses (calculated measurements) as well as single survey responses (single Likert measurements). Student measurements that significantly changed are in bold.

fied validated surveys to assess student engagement to administer prior to the schools starting online classes (Table 1) (43–46). We also rapidly submitted and received IRB approval (IRB_2020_02). Using academic listservs including the Ecological Society of America (ESA), the Association for Chemistry Education (ChemEd) and the Society for the Advancement of Biology Education (SABER), we immediately recruited undergraduate biology and chemistry instructors who could send the surveys to their students. Instructors provided their class with a Qualtrics link that included a

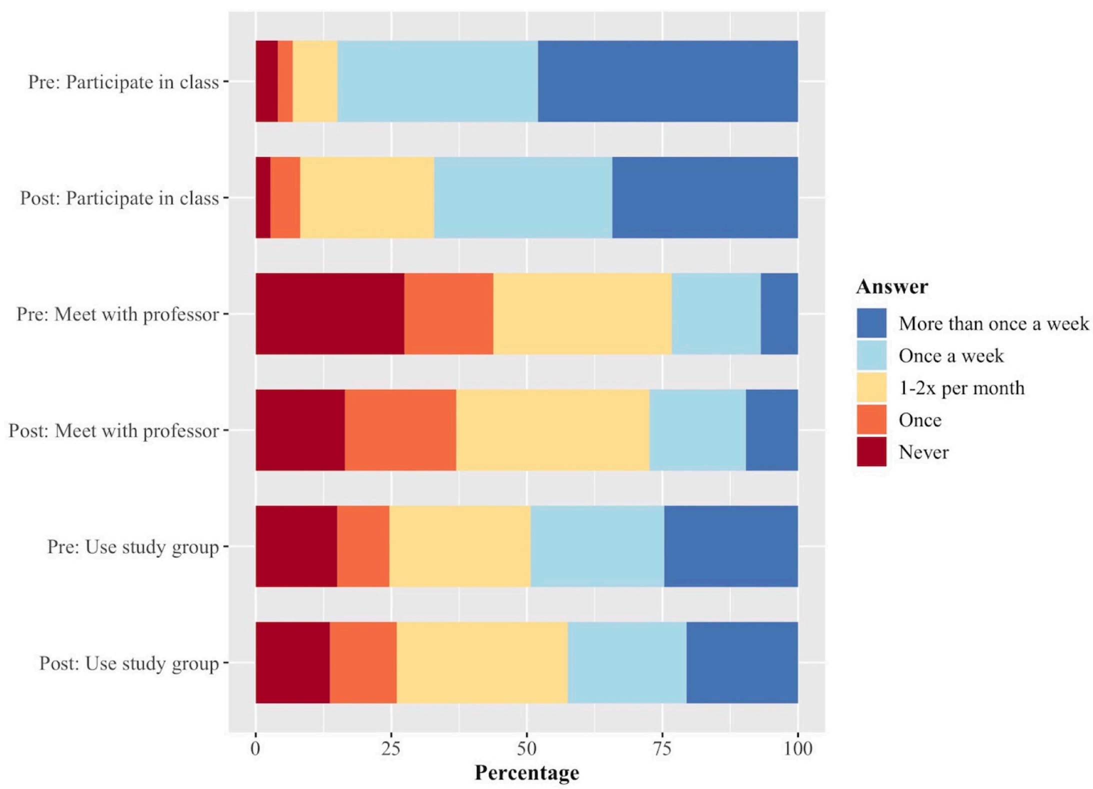

FIGURE 1. Percentage of student behavioral engagement before (Pre) and after (Post) the COVID-19 emergency transition to online learning. Students self-reported the frequency of their behavior on a five-point Likert scale for class participation, meeting with the professor outside of class, and using a study group.

consent form and survey to be completed prior to starting the online portion of the class (pre-) and again at the end of the semester (post-).

We collected student demographic and academic information using the Qualtrics survey software. We asked open-ended questions including name (for matching pre/post survey results), their university, which science course they were taking, and what date their class was moving/had moved to the online format. We also asked multiple-choice questions for gender and race/ethnicity (see Appendix 1). We grouped race/ethnicity into Persons Excluded [from STEM] due to Ethnicity or Race (PEER) (47) and non-PEER. The first includes those who identify as African American, Latinx/Hispanic, and First Nations (Native Americans, Pacific Islanders, Native Hawaiian, or Native Alaskan), or mixed races that include one of these groups.

Students completed a survey with questions covering topics within behavioral, cognitive, and emotional engagement. The survey included 63 five-point Likert-style questions, along with three to five short-response questions, depending on whether the questions were on the pre- or the post- survey (Table 1; full survey questions can be found in Appendix 1). This paper will only focus on quantitative questions. We adapted and selected published surveys on self-efficacy, sense of belonging, attitude toward science, and anxiety (broken down into stress and value) (Table 1). Additionally, we added three questions for students to self-report the frequency at which they engaged in the following behaviors: participating in class, meeting with their professors outside of class, and studying with peers outside of class.

Student responses were paired pre/post for all students who completed both surveys. Likert questions that had text answers, such as those related to behavioral engagement, were converted to a five-point Likert scale (0 to 4 points). Students' overall scores in each category (e.g., sense of belonging) were calculated based on their positive answers. If negative questions were included in the survey, such as with the attitude survey, the positive and negative responses were summed and then compared separately, and then the negative response total scores were subtracted from the positive response total for an overall score. These summed quantitative pre- and post- student responses were analyzed using a matched pairs *t*-test in JMP15 (SAS 2020). Because the attitude construct is composed of multiple subconstructs, we also evaluated the summed quantitative pre- and post-student responses for each of the subconstructs separately, e.g., real world connection to biology, enjoyment of biology, problem-solving synthesis, problem-solving effort (33). All graphs were made in R using ggplot2 (48).

Scores were calculated separately for the pre- and post-surveys for the behavioral, cognitive, and emotional parameters and for an overall measurement of engagement. We calculated a score for behavioral engagement by adding the Likert scores for each behavior-related question (see Appendix 2 and Table 1). We then calculated a normalized behavior score by dividing the sum of the students'

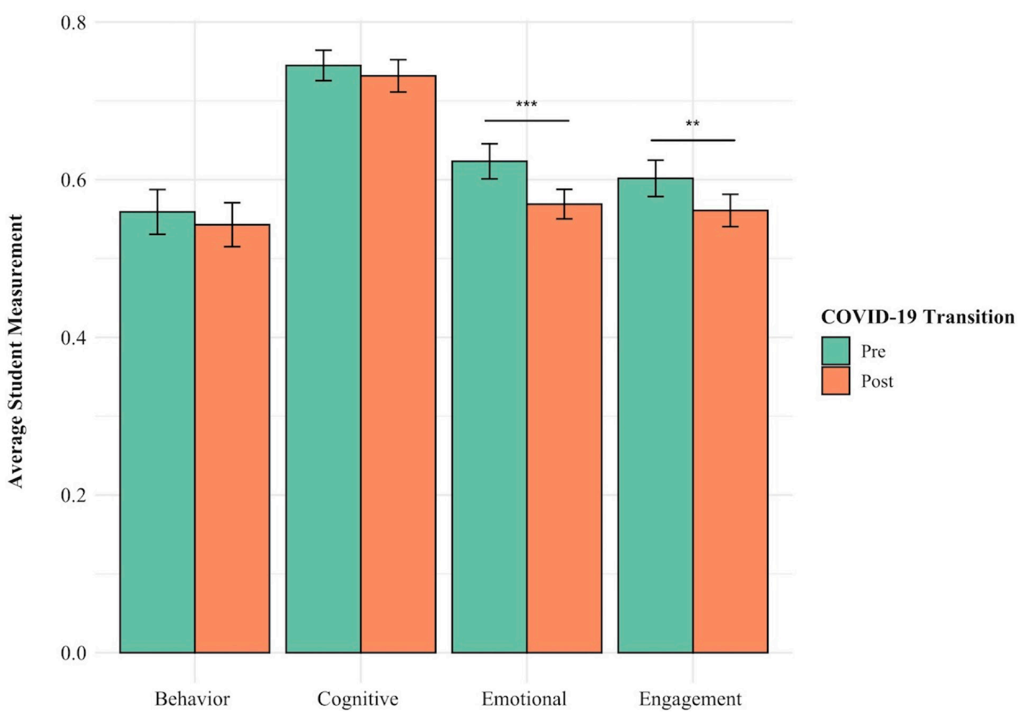

FIGURE 2. Students' overall behavior, cognitive, emotional, and engagement scores before (Pre) and after (Post) the COVID-19 transition to online learning. Each score was linearly scaled to a range of 0 to 1 for graphing. Error bars are ± 1 standard error. **, $p < 0.01$; ***, $p < 0.001$.

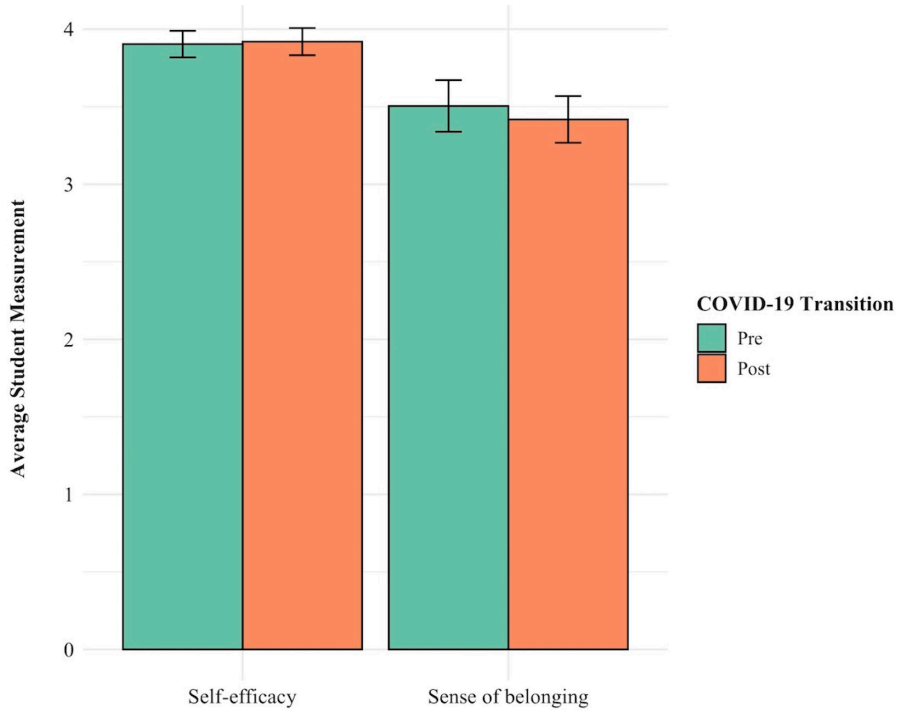

FIGURE 3. Cognitive engagement of students before (Pre) and after (Post) the COVID-19 transition to online learning. Calculated self-efficacy and sense of belonging measurements were standardized to a value out of 5 for this graph. Error bars are ± 1 standard error.

behavior answers by 12, the total possible points for the highest frequency of interactive behavior. We performed a similar normalization calculation for cognitive and emotional engagement by adding the survey answers that corresponded to the appropriate questions for each category and dividing the sum by the total possible points for all positive responses: 70 points for emotional engagement and 100 points for cognitive engagement. We then calculated a pre- and postengagement score by multiplying the normalized cognitive, emotional, and behavior scores. Finally, we used a matched pairs *t*-test in JMP12 (SAS 2020) to look for significant changes in the normalized behavior, cognitive, and emotional engagement scores as well as the overall engagement score. We also calculated a change-in-engagement score by subtracting the pre- from the postengagement scores, and we then used a least-squares test to assess differences across gender and race/ethnicity demographics.

RESULTS

We surveyed undergraduate science students at 23 different higher education institutions across the United States, including primarily undergraduate institutions, community colleges, and research-intensive institutions. We had 231 students complete the pre-survey and 141 students complete the post-survey. Of these surveys, 73 students completed both the pre- and post-surveys for matched responses, and these responses became our final dataset. Of the 73 matched students surveyed, 76% were female and 24% male, and 60% of students attended primarily undergraduate institutions. The majority of responders identified as non-PEER (79%), while 21% identified as PEER (Appendix 3).

Behavioral engagement

The matched students' behavioral engagement showed significant changes in both the frequency of participation in class and frequency of meetings with professors between the start of the transition (pre-survey) and the end of the semester (post-survey) (Table 2, Fig. 1). Students reported more frequent participation in the class at the beginning of the transition to online classes (84.9% participation in class once a week or more than once a week) than at the end of the semester (67.1%; df = 72, *t*-ratio = −2.8169, $p = 0.0063$). These results were not significantly different when looking across genders or race categories (PEER vs. non-PEER students). Students reported meeting with their professors more frequently (at least once a week) at the end of the semester (27.4%) than at the beginning of the transition (23.3%; df = 72, *t*-ratio = 1.82, $p = 0.0358$). Students did not report statistically significant differences in frequency of meetings with study groups before the transition to online learning compared with the end of the semester ($p = 0.4366$). We calculated an overall score for behavioral engagement, from the frequency students reported engaging in the activities described above, which did not significantly change pre/post ($p = 0.49$; Fig. 4).

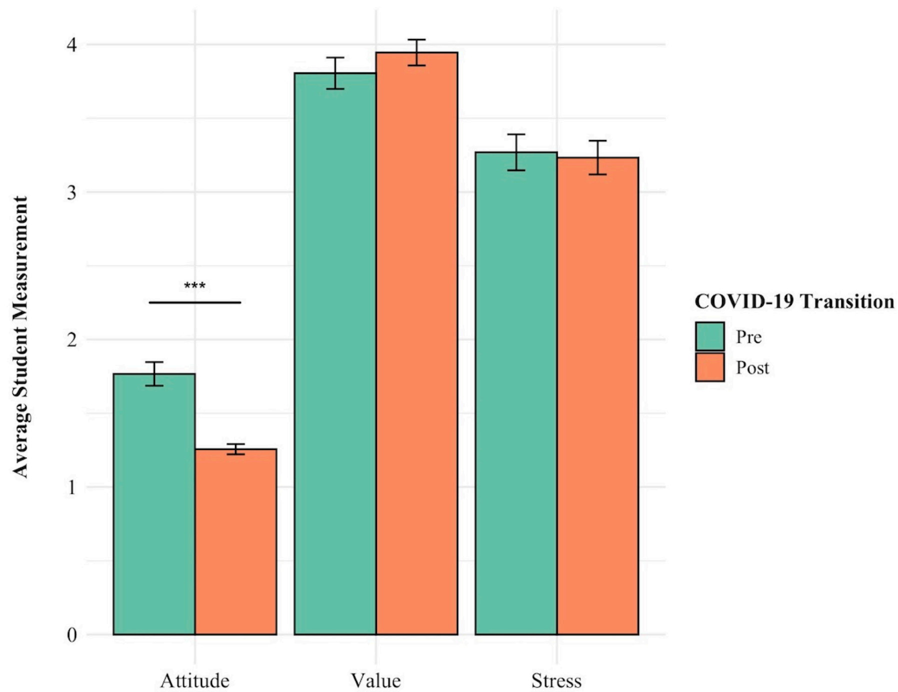

FIGURE 4. Emotional engagement of students before (Pre) and after (Post) the COVID-19 transition to online learning. Calculated perceived value of the course and stress were standardized to a value out of 5 for this graph. Error bars are ± 1 standard error. ***, $p < 0.001$.

Cognitive engagement

The matched data for students' cognitive engagement showed no change between pre- and post-surveys (Table 2, Fig. 2). Mean self-efficacy scores made a nonsignificant, slight decrease from 35/45 to 34.7/45 ($p = 0.7$). Students' sense of belonging scores also decreased slightly from a mean of 35.4/55 to 34.6/55 ($p = 0.24$). We calculated an overall score for cognitive engagement using the normalized sense of belonging and self-efficacy scores, which did not significantly change pre/postpandemic shift to online learning ($p = 0.29$) (Fig. 4).

Emotional engagement

The matched data for students' emotional engagement showed significant differences between the start of the transition and the end of the semester (Table 2, Fig. 3). Students' positive attitude toward science was significantly lower at the end of the semester (df = 72, t-ratio = 8.65, $p < 0.0001$). In fact, 87.6% of students' favorable attitude toward science scores decreased, while 60% of students had an increase in their negative attitude toward science between the pre- and post-survey. On average, a student's favorable attitude toward science score decreased by 14.1%. Anxiety was measured as "value" versus "stress." The students' perception of the value of the course, or the value students felt the course provided to them, their lives, and their future careers, increased marginally significantly ($p = 0.0563$), while their stress did not show significant change pre/post ($p = 0.6686$). When the value and stress factors were combined for an overall anxiety score, there was an increase in anxiety by the end of the semester (df = 72, t-ratio = 1.6, $p = 0.0563$). Before the transition to online learning, students reported a 30.4/40 anxiety value score, while they reported a 31.6/40 score at the end of the semester. There was also no significant difference between or across genders or race categories for either anxiety or attitude (p values all > 0.1). We used the attitude and anxiety scores to calculate an overall emotional engagement score which decreased significantly from pre- to post- surveys (df = 72, t-ratio = −3.54, $p = 0.0007$; Fig. 4).

For each of the attitude subconstructs, we observed significant differences in pre- and post- scores. Student scores for real-world connections, enjoyment of biology, and problem-solving effort all declined by the end of the semester (df = 72, all p values < 0.001). Student scores for problem-solving synthesis increased by the end of the semester (df = 72, t-ratio = −3.29, $p = 0.002$) (Appendix 3).

Overall engagement

We calculated an overall score of engagement using behavioral, cognitive, and emotional engagement scores (Fig. 4). The students' overall engagement decreased significantly during the spring semester (df = 72, t-ratio = −2.75, $p = 0.0075$).

DISCUSSION

Successfully recruiting and retaining participants for education research is especially challenging during times of crisis (9). Of the 231 students who completed the pre-survey, 32% returned to complete the post-survey. While men and women had nearly identical return rates to the post-survey (32.3% and 31.9%, respectively), only 22% of PEER students returned, compared with a return rate of 33.5% for non-PEER students. The reduced survey return rate of PEER students may partially be due to the disproportionate impact that COVID-19 had on PEER students, as indicated by other biology education research (49). Students overwhelmed by the crisis, either academically or otherwise, are not likely to participate in volunteer research (9). Given the importance of identifying and ameliorating educational disparities, our potential inability to survey and evaluate the most vulnerable students is a limitation to this study. Additionally, we did not collect data to compare traditional students who lived on campus with commuter students who would not have experienced the disruption of vacating campus student housing.

Behavioral engagement

While we did not see an overall shift in students' behavioral engagement, student behavior did change in several specific ways. Students spent significantly less time participating in class and more time meeting with professors outside of class. The less frequent participation in class may indicate that either classes were less focused on active learning due to professors struggling to create engaging activities (Walsh et al., submitted) or that students felt less inclined to participate in the active learning that was occurring. One study found a direct positive relationship with the level of student participation in classroom discussions and sense of belonging and an inverse relationship between participation and academic stress (50). However, we found that when the frequency of participation in class declined there was no change to sense of belonging or academic stress. Students reported a slightly significant increase in the frequency they met with professors outside of class. We hypothesize that the ease with which students were able to contact a professor, via Zoom or other video-conferencing software synchronously, or e-mail, asynchronously, without having to leave their homes, removed the barrier of having to physically travel to the professor's office. The more flexible schedules afforded by remote learning may have increased the frequency with which students could communicate with professors, as professors were more willing and able to accommodate student schedules (51). So, while students did not demonstrate a shift in the overall time they participated in behavioral engagement, the areas of behavioral engagement they prioritized changed, primarily from in-class participation to out-of-class communication with instructors.

Cognitive engagement

There was no change in students' overall cognitive engagement, nor in self-efficacy or sense of belonging, two parameters that instructors hope to cultivate steadily throughout the semester (52). Research indicates that it is more difficult to cultivate a sense of belonging in an online environment when compared with an in-person class; mitigating this discrepancy requires online teaching assistance or peer assistance (53, 54), both of which were likely unavailable during COVID-19. Self-efficacy increases when students are provided opportunities to master skills (55, 56), and with the unchanged self-efficacy scores in our study, students may not have had the same opportunities to master the skills they would have during in-person classes. While a decrease in self-efficacy as a result of increased stress and anxiety could have important impacts on student persistence and performance in classes (57), even a lack of change should be considered problematic when improvement is considered one of the basic unwritten goals of any course. A lack of positive change is unfortunate and may indicate that students did not continue to cultivate cognitive engagement once they moved into the online learning setting. Identifying best instructional practices to promote self-efficacy and sense of belonging should be prioritized for education research during emergencies.

Emotional engagement

Our data showed a significant change in emotional engagement, largely driven by a highly significant decline in students' attitude toward biology score despite a slightly positive increase in students' perceived value of the course. Attitude toward science, as measured by the CLASS-bio survey, compares novice and expert perceptions of biology (33). A decline in the score indicates that instead of students becoming more expert during the course of the semester, the students actually became more novice in their perceptions of and attitudes toward biology. Ideally, during a biology course, the students become more aligned with expert perceptions, opinions, and attitudes toward biology. Instead, we saw that students' attitudes and opinions about biology having real-world connections was less in line with expert views by the end of the course than prior to the transition to online learning. This was also true for students' personal interest in biology and their attitude toward using biology in problem-solving. We separated problem-solving into "effort" (e.g., I enjoy explaining science ideas that I learn about to my friends) and "synthesis and application" (e.g., If I get stuck on a science question, there is no chance I'll figure it out on my own) since the latter includes all negative attitude questions (33). We found that these both significantly changed, but in opposite directions: effort declined during emergency remote teaching while synthesis and application increased. Both of these changes indicate that students' responses at the end of the semester were significantly less in line with expert responses than prior to emergency remote teaching. It is not uncommon for attitude toward science to decrease slightly between pre- and posttests (58). However, the researchers are not aware of any studies where the decline in students' attitude toward biology was as high as what we saw. These results are disturbing to the researchers, as they indicate that, while the transition to online learning had a slightly positive impact on the students' perceived value of the class, their overall attitude toward biology and their perceived usefulness of biology for society significantly declined. Further research is needed to shed light on what caused this decline. We would be interested in the question of whether this larger decline in the attitude toward science correlated with an increase in overall science denial or with the narrower issue of the negative portrayal of science/health/epidemiology in the media during the spring of 2020. We are still in the process of analyzing the qualitative responses we collected from students about their stress, their barriers to accessing online learning, and their opinions regarding the actual cost and benefits of online learning. Hopefully, the qualitative data will shed light on this important question.

Overall engagement

Overall, we saw a significantly negative shift in student engagement from the in-person to the online learning environment, largely driven by emotional engagement, and, within that parameter, principally students' decreased positive attitude toward science. Unfortunately, we do not have midpoint data to identify when these declines happened or whether the declines occurred steadily throughout the second part of the semester.

CONCLUSION

It is critical that education researchers capture the experiences of faculty and staff as well as those of students (Harper, AERA-OECD Webinar, 23 September 2020). In addition to improving professional development, surveying faculty could shed light on our student results and potentially lead to solutions to problems experienced from both sides of the equation. In a nationwide survey of biology faculty that we conducted, many expressed frustration with the challenges involved in losing in-person classes and keeping students engaged (Walsh et al., submitted). Despite these logistic and pedagogical difficulties, when asked to describe a memorable moment of teaching online during the pandemic, faculty often recalled getting to know their students on a more personal level, as well as purposeful acts of kindness and empathy, either by students or by the faculty themselves. In our future research, we will assess student engagement and science practice learning in lab courses, as opposed to lectures, due to the plethora of different modalities for laboratory instruction that arose out of COVID-19. Fall 2020 lectures were either in-person or online, thus we decided to shift our focus to lab courses, which included a larger variation in instructional modality.

Student engagement plays a crucial role in students' motivation, self-regulated learning, retention of information, general well-being, and other factors that influence a student's academic achievement (59, 60). This is especially important during emergencies involving an abrupt change in educational setting, when many factors that influence academic success are disrupted. Due to COVID-19, students all over the world were forced to quickly give up the campus communities that helped sustain their educational success. As students moved away and replaced their classroom experience with distance learning, they were left with few options for a stable, established learning environment (qualitative data, Callis-Duehl *et al.*, unpublished). Previous research on education during emergencies is scant (61). We know that limited amounts of stress have mixed outcomes on students' memory and learning, but little is known about how the sudden onset of traumatic events influences these factors in students (62). Thus, the specific goal of this study was to identify how important events, such as a shift in educational setting due to the COVID-19 pandemic, influenced student engagement. Knowing that cognitive engagement stagnates when emotional engagement declines, we can better construct mechanisms for supporting student learning during disruptions to education caused by emergencies.

SUPPLEMENTAL MATERIALS

Appendix 1: Survey questions
Appendix 2: Student engagement calculations
Appendix 3: Demographic and subconstruct data

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