COVID-19 and Undergraduates with Disabilities: Challenges Resulting from the Rapid Transition to Online Course Delivery for Students with Disabilities in Undergraduate STEM at Large-Enrollment Institutions

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ABSTRACT

The COVID-19 pandemic caused nearly all colleges and universities to transition in-person courses to an online format. In this study, we explored how the rapid transition to online instruction during the COVID-19 pandemic affected students with disabilities. We interviewed 66 science, technology, engineering, and math (STEM) undergraduates with disabilities at seven large-enrollment institutions during Spring 2020. We probed to what extent students were able to access their existing accommodations, to what extent the online environment required novel accommodations, and what factors prevented students from being properly accommodated in STEM courses. Using inductive coding, we identified that students were unable to access previously established accommodations, such as reduced-distraction testing and note-takers. We also found that the online learning environment presented novel challenges for students with disabilities that may have been lessened with the implementation of accommodations. Finally, we found that instructors making decisions about what accommodations were appropriate for students and disability resource centers neglecting to contact students after the transition to online instruction prevented students from receiving the accommodations that they required in STEM courses during the COVID-19 pandemic. This study illuminates current gaps in the support of students with disabilities and pinpoints ways to make online STEM learning environments more inclusive for students with disabilities.

INTRODUCTION

The COVID-19 virus, which was declared a pandemic by the World Health Organization in March 2020 (WHO, 2020), majorly disrupted all sectors of American society, including higher education (Bedford *et al.*, 2020). Many college and university campuses closed during Spring 2020 to prevent the spread of the COVID-19 virus among students, faculty, and staff. Nearly all institutions of higher education opted to continue educating students during this time; as a result, colleges and universities rapidly transitioned their in-person courses to be delivered online (Smalley, 2020). The transition to online course delivery was not transient; more than 75% of institutions continued to deliver courses either completely or partially online during Fall 2020 (*Chronicle of Higher Education*, 2020), and many institutions continued online instruction in Spring 2021. The rapid transition to online learning is hypothesized to have created an array of novel challenges for all undergraduates, but there is concern that it disproportionately affected the learning of students from marginalized groups (Kantamneni, 2020; Kimble-Hill *et al.*, 2020). One particular group of undergraduates who likely

disproportionately experienced challenges during the transition to online instruction due to COVID-19 were students with disabilities[1,2] enrolled in science, technology, engineering, and math (STEM) courses.

Students with disabilities are notably underrepresented in undergraduate STEM majors; individuals with disabilities make up 26% of the U.S. population but only about 5% of the students enrolled in STEM undergraduate degree programs (Centers for Disease Control and Prevention, 2018; National Science Foundation, 2019). STEM courses and STEM careers are generally thought to be particularly unwelcoming to students with disabilities compared with non-STEM courses and careers (Alston and Hampton, 2000; Lee, 2011; Duerstock and Shingledecker, 2014; Wells and Kommers, 2020). For example, STEM instructors have been shown to have lower expectations for students with disabilities compared with students without disabilities (Dunn *et al.*, 2012), and undergraduates with disabilities majoring in STEM are less likely to receive accommodations than their peers majoring in other non-STEM disciplines (Lee, 2011, 2014).

Students with disabilities are also more likely than students without disabilities to have had their lives altered by the pandemic. Specifically, the stay-at-home orders put in place to prevent the further spread of the virus had a disproportionately negative effect on students with mental health and psychological disabilities (Sundarasen *et al.*, 2020). Additionally, those with disabilities are more likely to be food insecure and experience homelessness compared with those without disabilities (Coleman-Jensen and Nord, 2013; Coleman-Jensen, 2020). Both circumstances were exacerbated by unemployment during the pandemic (Gundersen *et al.*, 2020; Hsu *et al.*, 2020). Further, many individuals with disabilities have conditions that are immunocompromising, which means that contracting COVID-19 would have a disproportionately negative effect on the health of these individuals (Fung and Babik, 2020). These life-related challenges experienced by some students with disabilities likely affected their access to and learning of course content after the transition to online instruction.

Students with disabilities were also likely affected by the transition to online instruction, because those enrolled in college courses often require accommodations to facilitate their learning. These accommodations would have taken additional time and effort during the pandemic in a context wherein instructors were already overwhelmed and pressed for time. However, universities are legally mandated to provide appropriate accommodations to students with disabilities. There are two pieces of legislation that were passed to ensure that students with disabilities are adequately supported at colleges and universities. Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act (ADA) require that any college or university that receives federal funding must make course modifications to accommodate students with disabilities, as long as such modifications do not fundamentally alter academic programs in such a way that they change the nature of the program being offered (Section 504 of the Rehabilitation Act, 1973; Americans with Disabilities Act of 1990, 1990; ADA Amendments Act of 2008, 2008; Meeks and Jain, 2015). To help facilitate compliance with these pieces of legislation, many colleges and universities have created disability resource centers (DRCs),[3] which are offices that provide academic and social services for students with disabilities, diagnosed medical conditions, and diagnosed mental health issues.[4] These services include a variety of ways to support students, such as in-person testing services, support in communicating with instructors for alternative assignments, assistance with classroom infrastructure and modifications, and assistive technologies (Section 504 of the Rehabilitation Act, 1973; Americans with Disabilities Act of 1990, 1990; Gin *et al.*, 2020). For traditional in-person courses, DRCs are typically helpful in providing accommodations to students in the form of interpreters, note-takers, transcriptionists, and test-taking services; however, studies have shown that undergraduates may be unaware that the office of the DRC exists, uncertain of the range of services that a DRC offers, or have difficulties advocating for accommodations, as college is often the first time students with disabilities are responsible for doing this on their own (Brinckerhoff, 1994; Dowrick *et al.*, 2005; Eckes and Ochoa, 2005; Marshak *et al.*, 2010). We knew very little about the extent to which DRCs and instructors were able to properly serve students with disabilities during the transition to online course work because of COVID-19. We hypothesized that students with disabilities likely had trouble receiving their existing in-person accommodations due to the rapid nature of the transition to a unique learning platform.

As a final point, there is some evidence suggesting that students with disabilities face additional obstacles in any online

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[1]We recognize that there is a difference between "having a disability," which focuses on individual impairments versus "being disabled," which focuses on attitudes and structures of society that are actively disabling people. The former represents a medical model prospective of conceptualizing disability (Brisenden, 1986), whereas the latter is representative of the social or embodied models of disability (Siebers, 2008; Oliver, 2013). While this article contains both perspectives of conceptualizing disability, the authors do not believe the burden for resolving issues should be placed solely on the students when these issues are fundamentally a result of ableist structures, or discrimination and social prejudice against people with disabilities, within institutions (Hehir, 2002; Goodley, 2014).

[2]In this article, we chose to use person-first language, which places emphasis on the individual, to imply that the individual is foremost a person who happens to have a disability (National Center on Disability and Journalism, 2018). The American Psychological Association considers person-first language a general principle of bias-free language for talking about disability with inclusivity and respect (American Psychological Association, 2020). We acknowledge that there are some members of the disability community who prefer to use identity-first language, particularly the autistic community (e.g., Kenny *et al.*, 2016), the Deaf community (e.g., Lum, 2010), and the blind community (e.g., Vaughan, 2009). Others use both person-first and identity-first language depending on this disability question. While we respect and recognize these concerns, we have chosen to use person-first language (e.g., student with a disability), because we feel as though it is most generalizable to all students with disabilities.

[3]"Disability resource center" (DRC) is a term that is often used by colleges and universities to describe offices that support students with disabilities. While there are some institutions that use alternative names to describe these offices (e.g., accessibility resources, student access centers, accommodation services), we use "DRC" in this article, because it is term most often used by institutions.

[4]Although many individuals with mental health issues (e.g., depression, anxiety) may not consider their conditions a disability, these individuals are supported by DRCs, and they are considered students with disabilities by universities. Because of the stigma and assumptions that surround the term "disability," more inclusive language to describe the offices that support these students would likely broaden the reach of these offices.

learning environment. Challenges experienced related to online learning have been shown to lead to stress and other mental health concerns, particularly for students with disabilities (Lee and Oh, 2017; Fawaz and Samaha, 2020; Wang *et al.*, 2020). Additionally, students who are deaf[5] or hard of hearing can experience challenges with online learning management systems, access to properly formatted course content and materials, and communication barriers with instructors and other students (McKeown and McKeown, 2019). Finally, the online environment can make it more difficult for students to receive accommodations. An interview study of students with disabilities revealed that students felt as though they had less overall support and fewer accommodations for their disability in online courses compared with their in-person courses (Terras *et al.*, 2020). The need for more frequent interaction with both disability support services and individual instructors has been documented for students with disabilities in online courses (Phillips *et al.*, 2012; Terras *et al.*, 2015, 2020).

Taken together, the disproportionate impact of the COVID-19 pandemic on the lives of students with disabilities, the need to access accommodations during a rapid change in instruction, and the potential challenges that online courses present for students with disabilities suggest they likely experienced unique challenges in their college courses during COVID-19, and particularly in their STEM courses. However, no such challenges have been systematically documented.

CURRENT STUDY

In this study, we interviewed 66 students with disabilities from seven large-enrollment universities with the intent of answering the following research questions:

- To what extent were students able to access their previously established accommodations following the transition of in-person STEM courses to online instruction due to the COVID-19 pandemic?
- To what extent did the transition of in-person STEM courses to online instruction due to the COVID-19 pandemic present unique challenges related to students' disabilities, and how, if at all, were these challenges accommodated?

Previously, we have proposed a framework to address research questions related to creating more equitable education spaces for students with disabilities (Gin *et al.*, 2020). Specifically, we argued that when studying 1) the extent to which students with disabilities encounter challenges in education settings, 2) the extent to which they are being accommodated, and 3) what steps can be taken to enhance the experiences of students with disabilities, we need to answer these questions from the perspectives of individuals directly involved with the education of students with disabilities. This most often includes the students themselves, instructors, and those staffing DRCs. We argue that it is particularly important to examine these questions from all perspectives in the context of the COVID-19 pandemic, because while the transition to online learning likely

resulted in unprecedented challenges for students, instructors, and staff, it likely had the most direct effect on the experiences of students with disabilities. As a first step to explore the impact of the transition to online on students with disabilities during the pandemic, we began by examining our research questions from the perspective of students with disabilities. We recognize that both DRC staff and instructors experienced personal and professional challenges related to the COVID-19 pandemic (Scott and Aquino, 2020) and acknowledge that we are only presenting the perspective of students with disabilities in this research project.

METHODS

This study was approved by Arizona State University's Institutional Review Board STUDY00011930.

Interview Recruitment

We recruited undergraduate students with disabilities enrolled in STEM courses from large-enrollment institutions (>10,000 students) based on the Carnegie Classification of Institutions of Higher Education (Carnegie Classifications, 2020). We intentionally targeted institutions that serve a large number of students to increase the number of students with disabilities that we would reach. We sent an email to each director of the office that serves students with disabilities at each large-enrollment institution at the end of the Spring 2020 semester and requested that the directors forward our recruitment email for the interview study to registered students with disabilities at their institutions. This email was meant to reach all students who were registered to receive accommodations at those institutions. The recruitment email referenced that the goal of our study was to conduct interviews with undergraduate students with disabilities in STEM courses about their experience with the transition to online course delivery as a result of the COVID-19 pandemic. A copy of the email sent to directors and the recruitment script for students can be found in the Supplemental Material. We emailed a total of 150 directors. Of the 150 directors contacted, seven (5%) agreed to forward the interview recruitment to their students with disabilities. Sixteen directors (11%) declined to forward the email, 53 directors (35%) opened our email but did not respond, and the remaining 74 directors (49%) received our email but did not open it. Students were incentivized with a $15 Amazon gift card to participate in the study. The institutions from which students were recruited include two very high research activity (R1) institutions, three high research activity (R2) institutions, and two master's-granting institutions.

Interviews

We developed an interview script to explore the extent to which students with disabilities enrolled in STEM courses were impacted by the transition to online instruction as a result of the COVID-19 pandemic. Before conducting interviews with study participants, we completed two think-aloud interviews with undergraduates with disabilities to ensure that each question was properly interpreted (Trenor *et al.*, 2011). After the first think-aloud interview, we revised some of the questions to make them clearer. No additional revisions were needed after the second think-aloud interview because all questions functioned as intended. The interview questions probed the challenges that students may have experienced with the transition

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[5]The "d" in "deaf" is often capitalized when referring to individuals who are prelingually deaf, communicate in sign language as their first language, and have their own sense of culture and identity (Padden *et al.*, 2009). We use the lowercase "deaf" in the remainder of the article, because we are simply referring to the condition of having hearing loss.

to online instruction, their experience with the processes of being accommodated in an online format, and any recommendations for improving the experiences of students with disabilities in online STEM courses (see the Supplemental Material for a copy of the interview script).

We interviewed 66 students with disabilities from seven institutions about their experiences in their STEM courses during the Spring 2020 semester. The semistructured nature of the interviews allowed us to explore emergent topics within a single interview that may not have been present in all interviews with students. The interviews were approximately 45 minutes in length. Interviews were audio-recorded and transcribed. In a reminder email to participants, we offered to arrange accommodations for the interview if needed (e.g., interpreters). However, we did not have any students use such services. Pseudonyms were assigned to protect the identity of each student, and quotes were lightly edited for clarity. Following the interview, students were given a brief post survey that contained a suite of demographic questions as well as questions about the specifics of their disabilities. A copy of the post survey can be found in the Supplemental Material.

Interview Analysis

We used inductive coding methods to identify themes from the interviews (Birks and Mills, 2015). One author (L.E.G.) reviewed 14 of the interviews (21%) independently and took detailed analytic notes to identify initial themes in the data and developed an initial codebook. Two researchers (L.E.G. and F.G.) then each reviewed a different, randomly selected 14 interviews to confirm the presence of the existing themes and to identify any emergent themes in the data that were not accounted for in the initial codebook development. The researchers used constant comparison methods to verify that quotes within a category were similar enough to one another and not too different to warrant the creation of a new theme (Glesne and Peshkin, 1992). The two researchers finalized the codebook, which is included in the Supplemental Material. Then, they used the final codebook to independently code another set of 14 interviews (~21% of all interviews). The researchers compared their codes and achieved a Cohen's κ interrater score at an acceptable level (κ = 0.94; Landis and Koch, 1977). One researcher (F.G.) then coded the remaining 52 interviews.

Classification of Disabilities

Students reported their disabilities by selecting from a list of common disability categories and/or writing in a disability or diagnosed medical condition if it was not present on the list. Students had the option to report one or more disabilities on the post survey. A complete list of the specific types of disabilities that students reported can be found in the Supplemental Material. For this research, we chose to organize disabilities into categories by type (Gin *et al.*, 2020). These disability types included: chronic health condition (e.g., diabetes), hearing loss (e.g., deaf), learning disability (e.g., dyslexia), mental health/psychological disability (e.g., depression), physical disability (e.g., spina bifida), and vision loss (e.g., blind). We recognize that there are debates about how specific types of disabilities should be categorized. For example, there is some contention regarding classifying disabilities such as autism and attention-deficit/hyperactivity disorder (ADHD) as learning disabili-

ties (Mayes *et al.*, 2000; Budd *et al.*, 2016); however, we have chosen to categorize these disabilities as learning disabilities, because we hypothesize that students with autism and ADHD experience academic challenges in online learning environments that are more similar to those of students with other learning disabilities compared with students with mental health/psychological disabilities. It is also important to note that the personal experiences of individuals, even with the same type of disability, are unique (Brown, 2002; Shakespeare, 2006). Thus, we caution against making generalizations concerning all individuals who share a disability type or specific disability.

Analysis by Disability Type

In our results, we chose to present themes that were mentioned by at least 10% of students with disabilities. There were many notable individual experiences and ideas that were shared during the interviews, and we acknowledge that challenges shared by only a few students are still relevant. However, one goal of this study is to highlight potential ways in which DRCs and instructors can best serve students in these circumstances. As such, we chose to present the challenges that were most commonly shared among students in this study. We caution readers that, because of this choice, our findings may be more representative of specific groups of students with disabilities as certain groups were more prevalent among our interviewees. However, it is important to note that many students in the study identified with having multiple disabilities. Specifically, 56% of our sample (37 students) reported having at least two disabilities, and 14% (nine students) identified having three or more disabilities; this is consistent with other studies showing that disabilities are often co-occurring (Copley and Ziviani, 2004; Sareen *et al.*, 2007; Haydicky *et al.*, 2012). In the interviews, we explicitly asked students to describe how aspects of the transition to online education specifically affected each of their disabilities and found that students often could not disentangle how an aspect of online education affected a particular aspect of a single disability. This was not unexpected, given the overlapping nature of how disabilities may affect individuals (Merikangas *et al.*, 2007; Karalunas *et al.*, 2018). As such, we chose to leverage the qualitative nature of this study to identify challenges that were commonly experienced by students with disabilities broadly and to not make overarching claims about how students in specific disability groups were affected. For transparency, we report each of the students' disabilities next to their pseudonyms when a quote is presented and display tables showing what percentage of students with a particular type of disability reported each theme. However, we caution against making assumptions about how prevalent a challenge may be for any particular type of disability; notably, some disabilities (e.g., such as vision loss and hearing loss) are represented by only a small number of students in the data set.

Finally, we intentionally did not interview students without disabilities, because our research questions were focused on the experiences of students with disabilities and not how those experiences compared with the majority group. This study design mirrors others aimed to describe the experiences of students in underrepresented groups in science (e.g., Carlone and Johnson, 2007; Cooper and Brownell, 2016; Cooper *et al.*, 2020; Leyva, 2016; Leyva and Alley, 2020).

Positionality Statement

The author who conducted the interviews has a physical disability (L.E.G) and revealed his disability to students before the start of the interview in effort to elicit a more comfortable and direct conversation (Kvale, 1996). L.E.G. reported a perceived mutual level of understanding with the participants, particularly those with visible disabilities. Additionally, L.E.G. drew from his personal experience navigating STEM undergraduate education as an individual with a disability and getting accommodations from a DRC as he developed the initial rubric. Further, multiple members of the author team have diagnosed concealable identities, which would be supported by a DRC (e.g., anxiety, depression). These specific author identities helped inform this work. Three authors (L.E.G, S.E.B., and K.M.C.) were teaching courses that transitioned to online instruction during Spring 2020, and the fourth author (F.G.) experienced the transition online as an undergraduate student. All authors have conducted previous research on the experiences of students with disabilities in active-learning classrooms (Gin *et al.*, 2020).

RESULTS

Demographics

A total of 66 undergraduate students participated in our interviews. A summary of the disabilities represented and general participant demographics are reported in Table 1. Additional participant demographics, such as caregiving status and household income, can be found in the Supplemental Material. Mental health/psychological disabilities were the most common disability type reported by study participants (65%), followed by learning disabilities (55%). Participants were primarily women (61%), white (62%), and continuing-generation college students (67%). It was most common for students to be in at least their fourth year of college (41%), to be enrolled in at least two STEM courses in Spring 2020 (82%), and to be at an R2 institution (45%).

Finding 1: After the Transition to Online Instruction Due to the COVID-19 Pandemic, Students with Disabilities Were Unable to Access Accommodations and Campus Resources That They Normally Used for In-Person Courses

In the interviews, students with disabilities described how integral accommodations and campus resources are to their success in undergraduate STEM courses and in college more broadly. They explained that they were unable to access many of these accommodations and resources after the transition to online instruction because of the COVID-19 pandemic. We identified four accommodations or resources that students accessed before COVID-19 that they were unable to access, or had difficulty accessing, after the transition to online instruction; each was mentioned by at least 10% of all students (Table 2).

Lack of Reduced-Distraction Testing Environment. On college campuses, DRCs often house testing centers where students with disabilities can take their exams in a reduced-distraction environment and for a longer length of time. Students who regularly used the testing center for a reduced-distraction environment no longer had access to such an accommodation once courses were moved online. Students such as Scarlet and Tom reported that taking exams at home was particularly difficult without their reduced-distraction testing environment, because they were often disturbed by their home surroundings while taking STEM exams.

> Scarlet (learning disability and mental health/psychological disability): "In-person accommodations like the testing center, I don't [have] now. I'm just taking [my exams at home] (…) It has been hard, because I relied on the testing center. I knew where I was taking my exam. I knew the people at the testing center. Now, I'm living with my family, because I moved back home, so there's definitely other distractions in my house that I didn't have at the testing center, like a younger sibling. There are added stressors."

> Tom (mental health/psychological disability): "Since I was taking [my exams] at home, I was not able to be in a distraction-free environment. That made it really challenging to take tests. When I go into the [DRC] and take tests, I have my own kind of cubby, there's no noise, nobody's tapping pencils or doing anything that would normally kind of set me off. And so I really liked having that, but when I'm [at home] I have five animals, so they're running around and then people are coming in and out. Also my parents are there, so there's TV noises. There's just no way for me to take a test without any distractions."

While these students highlighted difficulties with taking tests from home, others offered concrete suggestions that would have made testing easier for them, such has having COVID-safe socially distant testing environments on campus (e.g. converting classrooms into testing rooms) for students who lived near campus. Additionally, students suggested exams could be open for longer periods of time to be taken whenever possible, which would allow students with multiple distractions, multiple people working from home, or multiple people using the Internet to take an exam at a time that worked best for them.

Extended Test Time Was Not Properly Administered. Students with disabilities also commonly receive extended time to complete their exams. Once exams started being proctored in an online environment, as opposed to in a testing center, some students, such as Eva and Bella, reported that they experienced issues with receiving the necessary extended test time due to the way tests were administered in the online format. Some instructors seemed to struggle to set up the proctoring software appropriately to allow for additional time for students to take exams.

> Eva (chronic health condition): "[The instructor] had the students with disabilities [take the exam during scheduled class time] with the entire class. After the class ended, he just kind of abruptly ended the Zoom call, but didn't specify where the students with disabilities should go. Because he just ended the call, we didn't really know what we were doing. And so that was stressful."

> Bella (learning disability, mental health/psychological disability, physical disability, and chronic health condition): "I've had some issues with testing where I was supposed to get double time, but I got kicked out at the same time as everyone else."

TABLE 1. Interview participant demographics

Demographics	All students *n* = 66 % (*n*)
Disability type[a]	
Chronic health condition (e.g., cancer, diabetes, multiple sclerosis)	33% (22)
Hearing loss (e.g., deaf)	6% (4)
Learning disability (e.g., dyslexia)	55% (36)
Mental health/psychological disability (e.g., anxiety, depression, PTSD)	65% (43)
Physical disability (e.g., cerebral palsy, spina bifida, dwarfism)	15% (10)
Vision loss (e.g., blind)	3% (2)
Gender	
Woman	61% (40)
Man	33% (22)
Nonbinary	2% (1)
Decline to state	5% (3)
Race/ethnicity	
Asian/Pacific Islander	9% (6)
Black/African American	3% (2)
Latinx	5% (3)
White/Caucasian	62% (41)
More than one race/ethnicity	12% (8)
Decline to state	9% (6)
College generation status	
First generation	30% (20)
Continuing generation	67% (44)
Decline to state	3% (2)
Academic year in school	
First year	14% (9)
Second year	18% (12)
Third year	24% (16)
Fourth year or more	41% (27)
Decline to state	3% (2)
Number of STEM courses enrolled in during Spring 2020	
One	18% (12)
Two	35% (23)
Three	24% (16)
Four or more	20% (13)
Decline to state	3% (2)
University type	
R1 doctoral universities	27% (18)
R2 doctoral universities	45% (30)
Master's colleges and universities	27% (18)

[a]Thirty-seven students reported having two or more disabilities, which is why the percentages add up to more than 100%.

Lack of Access to Note-Taking Accommodations. Another specific accommodation that some students with disabilities lost access to following the transition to online instruction was note-taking. Students in traditional in-person courses are often provided with a peer note-taker who assists them with their notes for a given class. Students who reported that they no longer had their note-taking accommodations described instances where they were not able to communicate with the peer note-taker or that the DRC no longer facilitated providing notes from their peer note-taker. As Ethan describes, given his physical disability, he found it difficult to physically write down or type information after the transition to online instruction because he did not have these note-taking services.

Ethan (mental health/psychological disability and physical disability): "I didn't have a note-taker [after transitioning to online instruction]. I didn't have the ability to get assistance with writing down things in class or writing down assignment information."

Ethan then goes on to describe that other alternatives were recommended to him, but he had difficulties accessing other technologies because they were cost prohibitive.

Ethan (mental health/psychological disability and physical disability): "I have had some people suggest that there are things out there you can purchase that will do a speech-to-text type of thing. (…) But it costs money, and if I'm not working,

TABLE 2. The percentage of students who reported trouble accessing a specific accommodation or resource after the transition to STEM online instruction due to the COVID-19 pandemic[a]

| | All students n = 66 % (n) | Type of disability | | | | | |
		Chronic health conditions (e.g., cancer, diabetes, Crohn's disease) n = 22 % (n)	Hearing loss (e.g., deaf) n = 4 % (n)	Learning disabilities (e.g., autism, dyslexia) n = 36 % (n)	Mental health and psychological disabilities (e.g., anxiety, depression) n = 43 % (n)	Physical disabilities (e.g., cerebral palsy, spina bifida) n = 10 % (n)	Vision loss (e.g., blind) n = 2 % (n)
Lack of reduced-distraction testing environment	33% (22)	32% (7)	0% (0)	36% (13)	37% (16)	30% (3)	50% (1)
Extended test time not properly administered	11% (7)	18% (4)	0% (0)	17% (6)	7% (3)	10% (1)	50% (1)
Lack of access to note-taking	11% (7)	18% (4)	0% (0)	11% (4)	16% (7)	10% (1)	0% (0)
Lack of access to tutoring/campus resources	24% (16)	36% (8)	25% (1)	11% (4)	28% (12)	30% (3)	50% (1)

[a]Some students reported multiple disabilities. Thus, the sum across rows does not equal the total number of themes reported by all students, which is represented by the first column.

I'm in a socio-demographic that doesn't have a lot of income. If you're disabled, you really need to have more money than a normal person to pay for all the extra things that you need to have because you can't function without them."

Lack of or Reduced Access to Tutoring and Other Campus Resources. Students with disabilities, in particular learning disabilities, are more likely to use and benefit from campus tutoring centers and other tutoring resources (Kowalsky and Fresko, 2002). A lack of access to these resources once the campuses shut down presented challenges for students like Pedro, who often used the in-person tutoring center for additional assistance with learning STEM course content. While some institutions attempted to move these services online, students often reported that they were either not as easy to access or that the resources were not as effective in an online format.

Pedro (learning disability): "There are tutoring lounges [on campus]. They are essential and they're closed. (…) It was quite a decrease in accommodation. [In-person] it was utilized to the maximum just to get the students to pass."

In addition to tutoring resources, students mentioned a lack of access to other campus resources, such as computer labs, libraries, counseling centers, and food pantries. While this affected all students, students with disabilities perceived that it especially affected them.

Renea (mental health/psychological disability): "Especially for students who don't have a lot of money, the therapists provided by the campus were a really big thing for me. They were really cheap and I was able to go see a therapist. But when the transition [to online] started they closed the health center, which also stopped all counseling. It was not good."

Sean (chronic health condition): "A lot of different services we have [on campus] shut down with little to no notice, which was really impactful especially if you needed to utilize some of that. Especially our Student Memorial Center. It has our Disability Resource Center, it has our Queer Resource Center, it has some of our food pantries. That shut down pretty quickly. There are a few other students here with disabilities that have issues with job security so a lot of them have to utilize things like our food pantry because they're not able to find work especially right now. So, I think that shutting down so quickly was a problem."

Finding 2: Students with Disabilities Experienced New Challenges after the Transition to Online Instruction Due to COVID-19 That Might Have Been Lessened with University-Provided Accommodations

Not only did the transition to online instruction due to the COVID-19 pandemic decrease students' access to previously established accommodations, but it also created a need for additional accommodations. Students with disabilities commonly described three challenges specific to the transition to online instruction that might have been lessened if they had been provided access to new accommodations (Table 3).

TABLE 3. The percentage of students who reported a unique challenge with STEM online instruction that may have been lessened with an accommodation[a]

	All students (*n* = 66) % (*n*)	Chronic health conditions (e.g., cancer, diabetes, Crohn's disease) *n* = 22 % (*n*)	Hearing loss (e.g., deaf) *n* = 4 % (*n*)	Learning disabilities (e.g., dyslexia) *n* = 36 % (*n*)	Mental health and psychological disabilities (e.g., anxiety, depression) *n* = 43 % (*n*)	Physical disabilities (e.g., cerebral palsy, spina bifida) *n* = 10 % (*n*)	Vision loss (e.g., blind) *n* = 2 % (*n*)
				Type of disability			
Issues with test proctoring technology	11% (7)	14% (3)	0% (0)	8% (3)	9% (4)	10% (1)	50% (1)
Reduced access to material or information	42% (28)	50% (11)	0% (0)	42% (15)	49% (21)	40% (4)	50% (1)
Inaccessible videos	21% (14)	32% (7)	50% (2)	22% (8)	23% (10)	20% (2)	50% (1)

[a]Some students reported multiple disabilities. Thus, the sum across rows does not equal the total number of themes reported by all students, which is represented by the first column.

Issues with Test Proctoring Technology. During online instruction, many instructors implemented new technologies to proctor exams in an online course setting. These online test proctoring programs, such as RPNow (www.psionline.com/platforms/rpnow) and Gradescope (www.gradescope.com), often allow for tests and exams to be timed, Internet browsers to be locked, and an audio/video recording of students to reduce academic dishonesty and maintain test integrity. However, these technologies often presented challenges for students with disabilities. For example, students reported that the test proctoring technology, such as having the video recording of themselves taking their exam, increased their stress and exacerbated symptoms of their disability while testing.

> Sal (learning disability): "I can say that the camera being on and recording me wasn't helping me because every time I looked back up at the screen to look for the next problem, all I saw was a picture of my own face being recorded. You know, almost all of my [previous] accommodations [during exams] are specifically to alleviate my anxiety so that my disability doesn't overwhelm me."

The proctoring also could interfere with students' disabilities, further exacerbating their anxiety during the test. For example, as Sherry describes, she is normally granted restroom breaks during her in-person testing as an additional testing accommodation for her chronic health condition. However, the online proctoring system would flag her video for academic dishonesty if she stepped away, which exacerbated her stress.

> Sherry (learning disability, mental health/psychological disability, chronic health condition, and vision loss): "Since I'm at home, I can't get up and take a break and come back without getting called out for maybe cheating. I have Crohn's disease. I couldn't even go to the bathroom during exams and that was stressful."

Students implied that they would have benefited from having specific accommodations for test proctoring systems. For example, formally allowing students to have breaks during testing, to leave the room for medical reasons, or allowing students to opt out of being recorded if it interfered with their disability could have greatly improved students' experiences with proctored exams and, likely, their scores on these exams. This assertion by students in this study is further supported by the results of a recent study reporting that online proctors make students uncomfortable, specifically students with high anxiety, which negatively impacted exam performance (Woldeab and Brothen, 2019).

Reduced Access to Material and Information. Students with disabilities mentioned that in-person courses typically allow for multiple ways of accessing course material. For example, if an instructor said something that students did not hear in an in-person course, they could ask a student sitting next to them, raise their hand and ask the instructor to repeat what was said, or approach the instructor after class. Students described that, once their course work transitioned online, there were often fewer ways to access course content that they missed or would want to access again. During the transition to online instruction, many instructors adopted synchronous lectures as a way to deliver material to students. That is, the instructor lectured to students during their typical class time via an online platform. Students described that it was often difficult in this environment to address questions to the instructor or to other students. These lectures were often not recorded as a way for instructors to encourage students to attend live; as such, students could not access this information after synchronous instruction. Additionally, students mentioned that they no longer had access to informal help and resources that they previously had been able to access when courses were taught in-person, such as being able to meet with an instructor before or after class. Some, but not all, instructors continued to hold office hours, so many students lost that opportunity to engage with the instructor to go over course material. Students like Oscar and Naomi summarized some of these difficulties.

> Oscar (learning disability and chronic health condition): "Often times you would see a professor around and ask 'Hey, do you have a minute? Can I ask a question?' So, now when you're getting into more complex theories and understandings, it's really hard to do over email."

Naomi (learning disability and mental health/psychological disability): "I am the type of person, especially with my dyslexia, where it is extremely helpful for me to see something and hear it being taught to me at the same time, and also writing it down myself. And that was really nice in my in-person classes, because the teacher was there teaching it with the formulas, writing it all down the board, and then also in different colors. That helped me a lot. When we switched to online, that was really different. She would share her Power-Point on [an online conferencing platform] and we couldn't really see her writing anything. It was difficult to have to look at that, look at my notes, and have to write down what she was saying too. She wasn't doing her personalized notes like she did in class or walking around to the tables and giving you that individual clarification that has always been extremely helpful to me."

Students, particularly students with learning disabilities, described that they would have benefited from access to all lectures being recorded and posted online so that they could access the material when they needed. This would allow for students to go back to areas of the lecture that they may have missed, pause lectures, and rewatch any parts of the lecture to help their understanding. Students specifically mentioned that this could be helpful if they missed part of the lecture or class period due to an issue related to their disability. Even if an instructor did not want to post a recording for the whole class, this could have been negotiated as an accommodation specifically for students with disabilities who would have benefited from it.

Video Delivery of Information Is Not Always Accessible. While students agreed that recorded lectures would be helpful for them, they also identified additional challenges that they experienced with regard to videos. Specifically, students noted that instructors relied more on videos after the transition online than they did during in-person courses; after the transition online, they often asked students to watch previously developed videos (e.g., YouTube clips) and sometimes provided recorded videos of themselves teaching. Students with disabilities pointed out that most of these videos posted for a course did not include closed captions. For example, students like Bertha noted that they normally placed themselves strategically in the classroom so that they could easily speech read. Speech reading involves lip reading, but also facial expressions, body gestures, or other aspects of the speaker to assess what they are saying (Hearing Loss Association of America–Washington State, 2013). However, this was often not possible after the course transitioned online because of how videos were recorded.

Bertha (hearing loss): "I definitely do a lot of speech reading [in in-person courses]. Seeing facial expressions, lip movement, and emotions when people are talking really helps me get like a full, well-rounded idea of what's going on in the conversation. Things that I might miss [if I cannot hear the] words, I can gather by the context of the conversation, like what their face is doing and that kind of thing. I cannot do this with online videos."

Additionally, relying on visuals in videos presented difficulties for students with vision loss, like Phillip.

Phillip (chronic health condition and vision loss): "Transitioning to everything being online, I'm spending so much more time staring at screens, a lot of smaller print since I'm using just a normal 15-inch laptop screen. [The impact of vision loss] definitely reared its head and showed up a lot more in this phase of education."

There are features and programs that can make videos more inclusive to help accommodate students with disabilities. For example, DRCs often have staff and other trained personnel to assist instructors with creating closed-captioned videos. There are also some free programs that instructors can use that caption videos automatically (e.g., www.Amara.org, www.DotSub.com). Additionally, students mentioned that there are existing assistive technologies that can help them, such as screen readers and text-to-speech programs, that make content more accessible to students with vision loss. For example, Zoom offers the ability to enable live transcription of a meeting and Google Slides and PowerPoint allow for presenters to make closed-captioning available to their audience. Even if DRCs did not have sufficient staff to help with more professional closed-captioned videos during the pandemic, instructors themselves still could have created closed-captioning on their videos.

Finding 3: Factors Related to Instructors and the DRC Delayed Student Access to Accommodations following the Transition to Online Instruction

Students in this study undoubtedly would have benefited from receiving specific accommodations after the transition to STEM online instruction during COVID-19. We were interested in identifying what factors prevented students from receiving such accommodations. Students reported a number of barriers stemming from instructors and DRCs that prevented accommodations from being delivered delivered efficiently and effectively (Table 4). We found that students reported that self-advocating was especially important if they wanted to receive proper accommodations during this unique time. This unprecedented pandemic overwhelmed institutional employees and presented significant personal and professional difficulties for instructors and staff (Adedoyin and Soykan, 2020; Marelli *et al.*, 2020). Because there were likely no protocols in place about how to handle a transition to online instruction in this time of panic, the purpose of this section is not to blame the shortcomings of instructors and DRCs, but to document the challenges that did arise for students with disabilities. Further, although this study focuses on the COVID-19 pandemic, these challenges for students with disabilities may occur in any future situation with online learning.

Instructors Did Not Consider Students with Disabilities and Their Needs when Transitioning to Online Instruction. Students in this study stated that sometimes their instructors did not consider the specific needs of students with disabilities as they transitioned their instruction online. Specifically, instructors often forgot that students in their classes received a particular accommodation, such as extended time on quizzes, as described by Joe.

Joe (learning disability and mental health/psychological disability): "My geology lab TA didn't give me double time on my

TABLE 4. The percentage of students who reported a barrier to receiving accommodations effectively and efficiently after the transition to STEM online instruction during COVID-19[a]

	All students n = 66 % (n)	Type of disability					
		Chronic health conditions (e.g., cancer, diabetes, Crohn's disease) n = 22 % (n)	Hearing loss (e.g., deaf) % (n = 4)	Learning disabilities (e.g., autism, dyslexia) n = 36 % (n)	Mental health and psychological disabilities (e.g., anxiety, depression) n = 43 % (n)	Physical disabilities (e.g., cerebral palsy, spina bifida) n = 10 % (n)	Vision loss (e.g., blind) n = 2 % (n)
Instructors did not consider students with disabilities	14% (9)	18% (4)	0% (0)	17% (6)	16% (7)	30% (3)	50% (1)
Instructors made assumptions about appropriateness of accommodations	24% (16)	23% (5)	0% (0)	22% (8)	23% (10)	10% (1)	0% (0)
Lack of information from DRC	17% (11)	18% (4)	0% (0)	19% (7)	16% (7)	40% (4)	0% (0)
Student was required to self-advocate for accommodation modifications	74% (49)	64% (14)	100% (4)	78% (28)	77% (33)	80% (8)	100% (2)

[a]Some students reported multiple disabilities. Thus, the sum across rows does not equal the total number of themes reported by all students, which is represented by the first column.

quiz. I just assumed he would know. I just assumed that the professor would tell him because I feel like that should be done by default."

Students also described instructors who did not realize that a student would still need an accommodation once the course transitioned online or who were overwhelmed by transitioning course work online and struggled to provide the necessary accommodations.

Terry (learning disability, mental health/psychological disability, physical disability, chronic health condition, and hearing loss): "I really had to fight with one of my professors to get accommodations because he's not very tech competent and it makes it really hard to get things and he's very specific about how you get things. So, I have to really work with my disability advisor and just hound the hell out of him to get what I need. I'm supposed to have the slides for one of his classes and I never get the slides sometimes and then I just have to fight him for it."

Instructors Made Assumptions about What Accommodations Were Appropriate. While many instructors tried to work with students and DRCs to provide students with accommodations in some way following the transition to online, some students reported that their instructors refused to give them the accommodations that they previously had access to or were registered to use after the transition. Specifically, some instructors made assumptions about what was appropriate or was not appropriate with regard to a student's accommodation without talking to the DRC. Given the lack of expertise for most faculty in issues related to students with disabilities (Lombardi and Murray, 2011; Love *et al.*, 2014; Murray *et al.*, 2009), it is likely inappropriate for them to make judgment calls about how to best support students with disabilities. Linda discusses how one of her instructors did not grant her extended time on an exam due to fear of academic dishonesty. While she was able to work with her DRC director to get some of her accommodations back, she was not able to get the particular accommodation that she was requesting in that specific STEM course.

Linda (learning disability and chronic health condition): "Some professors felt that because all of the lectures were online, like because I had access to the lecture notes and because we were at home, they didn't want to give me my time-and-a-half to take exams. They thought it was easier for me to cheat. Well, that's not always the situation when it takes me like five minutes just to fully understand what the question is asking. So that was definitely frustrating."

Other instructors, such as Alexandria's instructor, assumed that because they gave extended time to all students, that amount of time would be sufficient for students with disabilities who were regularly granted additional time on assignments and exams.

Alexandria (mental health/psychological disability): "The professors gave me less time (…) It's slightly unfair because I'm supposed to be given double time. Because it's online, they thought [the exam was] going to be easier, because it's an

open-book exam. So, they didn't give me double time, but that's not up to them. That's up to the DRC. So, I found that to be a disadvantage. I guess that they didn't follow the rules."

DRCs Did Not Provide Information about When and How to Adapt Accommodations for Online Instruction. Students with disabilities also reported that they felt as though they did not have access to sufficient information about how their accommodations would be adapted in an online learning environment. Commonly, students explained that they felt as though there was no plan or description of how their accommodations would change as a result of the transition to online. Students complained about the lack of communication and transparency from DRCs. As Sylvia described, students often felt as though the DRC did not communicate with them about the process of changing existing accommodations to better suit them in an online environment, and they did not feel supported by the DRC.

> Sylvia (mental health/psychosocial disability, physical disability, chronic health condition): "I didn't get much information regarding the transition [to online instruction] through disability services. I can't speak for everyone as a whole obviously, but I didn't get a lot of communication personally, so I didn't feel necessarily supported through disability resources."

Accommodations can be proactive, where they are put in place before a student encounters a challenge in class, or retroactive, where they are enacted after a student encounters a challenge in class (Gin *et al.*, 2020). Proactive accommodations often save students significant time and difficulty, because they can start the course with the accommodation. Lydia describes how it would have been helpful to have a list of online accommodations available to students as soon as the transition online started. This way, students could have proactively selected which accommodations they thought they would need. Unfortunately, no student we interviewed described having that opportunity.

> Lydia (mental health/psychological disability): "I think that would've been really good if the DRC would have offered to show just what is available for accommodations during [the transition to online courses]. That would have been really helpful. [Identifying common online accommodations] is one of the things that could potentially come out of this [interview]. Right? Because I don't think the DRC necessarily has things that are specific to online. At least I'm hearing similar things from other students where most of the accommodations have been developed for in-person courses, but some of them don't quite translate to online."

Similarly, Selena describes how she did not hear from her DRC at the beginning of the online transition and instead she had to reach out to her professors to understand how her accommodations would be modified.

> Selena (learning disability): "Man, I might regret saying this, but the Disability Resources here are not that great. We don't have a lot of people, it's underfunded. I'm the one who had to initiate it. I'm the one who had to email professors and be like, 'Hey, how's this going to work now online?' because [the DRC] wouldn't have really done it that well."

Students Had to Self-Advocate for Additional Accommodation or Modifications to Their Existing Accommodations. Because instructors sometimes did not consider the accommodations that students needed and because DRCs often did not facilitate the delivery of proper accommodations to students during the pandemic, students with disabilities described that they had to advocate much more than they typically do in order to receive proper accommodations after the transition to online course work. This often came in the form of having to make multiple phone calls or send multiple emails to their instructors or the DRC asking to work with them to adjust their accommodations for the online environment. All of this took up valuable time that could have been spent on the course material. For example, Terry highlights how online instruction presented new challenges related to his learning disability, which required a new accommodation; he needed videos of the instructor lecturing so that he could review content that he would have otherwise sought from those around him during in-person classes. These new challenges required him to self-advocate much more than usual.

> Terry (learning disability, mental health/psychological disability, physical disability, chronic health condition, and hearing loss): "I would say [I] definitely [self-advocate] a lot more than in-person classes. Especially with making sure I get captions on time and stuff. Like with my one professor who is the professor I've had to fight with, I've had to be like, 'Hey, I need you to send these [videos] to the DRC so I can actually have them.' And before that, it wasn't really a problem because, for the most part, my professors were pretty clear or I could ask other students in class if I didn't understand what was going on. Now I have to directly go to the professor and be like, 'Hey, I have a problem. I kind of need you to fix it,' or 'I have absolutely no idea what's happening in class.'"

Other students, like Linda, encountered instructors who made assumptions about what they, as a student with a disability, needed or did not need. In this instance, Linda had to advocate for herself not only with her instructor, but eventually with the DRC to receive the accommodation she required.

> Linda (learning disability and chronic health condition): "First, before I talked to my [DRC], I explained to the professor what my accommodations were, why I felt I needed them, why it was harder for me to be at home because being at home was a very big distraction. He still felt that I didn't need the extra time [on my exam]. And then my advisor [from the DRC], I talked to her and I explained exactly why I needed it. She ended up messaging him and they ultimately ended up working it out. I don't know what fully went on behind the scenes of that, but I did end up getting my time-and-a-half back."

Self-advocating can be emotionally exhausting for students, often because it requires multiple exchanges between students and the DRC or the instructor (Pfeifer *et al.*, 2020). In fact, Desiree, as well as other students in this study, described her experience with self-advocacy during the transition as a "fight."

> Desiree (mental health/physiological disability and chronic health condition): "[Self-advocacy] is a consistent thing. I feel like I'm fighting the school. It's always a fight. That's what I say

to myself now. It's always a fight. I can either just lay down and let it go or I need to actually keep fighting and asking and asking and asking to figure out who in my department can help me."

DISCUSSION

This study highlights that students with disabilities did indeed experience challenges related to the transition of in-person STEM courses to online instruction during the COVID-19 pandemic in Spring 2020. Specifically, students reported that they were unable to access many of the accommodations that they typically used in their in-person courses once their courses moved online. Proper accommodations are integral to the success of students with disabilities in college courses (Terras *et al.*, 2015; Pfeifer *et al.*, 2020). Indeed, the students in our study noted multiple accommodations that they felt benefited them in in-person courses and would have also likely helped them learn in an online environment, including reduced-distraction testing environments, extended test time, and note-taking. To make institutions more inclusive, we argue that, moving forward, instructors should be informed that a student's accommodations should apply to any learning environment that a student encounters during a course regardless of whether the course is offered in-person or online. Additionally, participants in this study emphasized that, before the pandemic, they used institutional resources that closed after course work and other services moved online. Some resources were directly related to students' disabilities. For example, some students with learning disabilities relied on tutoring centers, and some students with mental health disabilities relied on counseling centers. However, other resources were more general, such as food pantries and career centers, but arguably would have been disproportionately helpful to students with disabilities, as they would have been more likely than their non-disabled peers to experience food insecurity and trouble finding employment during the pandemic (Coleman-Jensen, 2020; U.S. Bureau of Labor Statistics, 2020). It is also important to acknowledge that not all students were near campus after instruction was transitioned online (e.g., out-of-state students may have moved back to their home states), further complicating some accommodations. For example, socially distanced on-campus testing accommodations would have only been helpful to students who still lived within commuting distance to campus. However, identifying ways to deliver accommodations and resources to students with disabilities during crises should be discussed by all institutions in preparation for future events such as pandemics, or more common weather events and other natural disasters that may result in the closing of institutions and transition to remote instruction for days, weeks, or months.

In addition, the online learning environment presented novel challenges for students with disabilities. Students listed specific challenges with online learning that could have been lessened or even completely ameliorated if accommodations had been in place. In the past 20 years, the ways in which instructors teach students has changed dramatically (Tikhonova and Raitskaya, 2018; Palvia *et al.*, 2018). However, increasing evidence suggests that students' access to proper accommodations is not keeping up with the rate of change in how students are taught. For example, robust evidence demonstrates that, on average, students learn more and fail less when they actively engage in their learning (Freeman *et al.*, 2014), which has led to the increasing adoption of active-learning instruction in STEM (American Association for the Advancement of Science, 2018; Stains *et al.*, 2018). In active-learning courses, instructors deploy an array of practices that were not necessarily common in traditional lecture courses, such as group discussions, clicker questions, and in-class worksheets. However, these activities often require additional accommodations that are not readily available to students (Gin *et al.*, 2020). It appears that an analogous problem is arising with regard to online education. The number of courses offered online was notably increasing before the COVID-19 pandemic, with some STEM bachelor's degrees being offered completely online (Allen and Seaman, 2013; Varty, 2016; Cooper *et al.*, 2019; Mead *et al.*, 2020). Studies have shown that students with disabilities feel as though they have less overall support and fewer accommodations for their disabilities in online courses compared with their in-person courses (Terras *et al.*, 2015, 2020). The rapid transition to online education only exacerbated an existing problem: the lack of standardized accommodations for online instruction. In this study, students identified an array of accommodations that could benefit students with disabilities engaging in online course work, including accommodations related to making videos more accessible, like providing closed captions; accommodations related to virtual test proctoring, such as allowing breaks for needs relating to students' disabilities; and accommodations related to content availability, such as recorded lectures. Students with disabilities likely benefit most when they can access an accommodation from the beginning of the term, as opposed to needing to seek out an accommodation after they have experienced a challenge in the middle of the semester (Gin *et al.*, 2020). As such, we encourage DRCs to identify and standardize accommodations related to online education that students with disabilities can select from when they identify their needed accommodations at the beginning of each term.

Legislation such as the ADA and Section 504 of the Rehabilitation Act of 1973 are in place to ensure that students with disabilities are accommodated in institutions of higher education. While the government acknowledged the need for flexibility in education during the COVID-19 pandemic (U.S. Department of Education, 2020), our research suggests that, in many cases, universities may have been in violation of these laws as their instruction transitioned from in-person to online instruction. These violations occurred both because students were unable to access their original accommodations and because accommodations related to the novel challenges of online learning were not provided. While deviation from these pieces of legislation was (and may still be) a notable problem during the COVID-19 pandemic, a potentially greater concern is the extent to which online education more broadly adheres to these laws. Notably, these pieces of legislation were written before online was a common modality for educating students and may benefit from being revised now that some of the content, such as references to classrooms, does not exclusively refer to physical spaces. Before the pandemic, some lawsuits had been filed by students with disabilities alleging that their university failed to provide proper accommodations in an online setting (e.g., Disability Rights Education & Defense Fund, 2019); however,

these cases gained little national or media attention, presumably because so few students with disabilities were engaged in online higher education. With the increasing adoption of online teaching (Allen and Seaman, 2013), institutions would certainly benefit from assessing how their DRCs and instructors abide by these pieces of legislation for online courses, not only for legal protection, but most importantly to ensure that their institutions are inclusive of students with disabilities.

Beyond considering specific student accommodations in the context of online course work, we would like to highlight that many instructional and institutional decisions that were made during the transition to online instruction resulted from ableist structures that have long existed in academia and STEM specifically. These are structures that actively discriminate against individuals with disabilities due to a belief that individuals with disabilities are inferior and that there is a need to fix individuals with disabilities (Hehir, 2002; Goodley, 2014). We argue that students with disabilities were mostly forgotten in the midst of the chaos of the pandemic because of how inherently ableist higher education is. We urge instructors, administrators, and higher education to more broadly consider the ways in which ableist beliefs may infiltrate decisions that are made that could be excluding or disadvantaging individuals with disabilities. Exam proctoring, timed tests, and required attendance are often framed as ways to increase integrity and accountability, yet all of these decisions could be considered ableist and exclusionary for students with disabilities. These instances of ableism, which have always been present in higher education, were made more visible by the ongoing pandemic and the transition to online instruction. Additionally, the competitive, unwelcoming, and sometimes "chilly" nature of STEM disciplines, which are often devoid of consideration of individuals' identities, has been proposed as promoting ableism in undergraduate STEM (Hall and Sandler, 1982; Seymour, 1997; Simon et al., 2017). There are unique linguistic and representational challenges that may arise due to the complexities of STEM content, such as the use of a specific vocabulary as well as models and illustrations that can be integral to the learning of STEM concepts (Mason and Hedin, 2011; Harshman et al., 2013; McMahon et al., 2016; Braun et al., 2018). For example, students who are blind or have low vision may experience difficulties with how certain symbols, equations, and concepts are communicated in STEM (e.g., unfamiliar tactile representations to convey figures or models, PowerPoint images without text descriptions, handwritten equations; Harshman et al., 2013). Additionally, students who are deaf or hard of hearing may be assigned an interpreter who does not have any experience in STEM, requiring the interpreter to learn the technical vocabulary to properly interpret (Hauser et al., 2008; Braun et al., 2018). Finally, it is common for STEM courses to rely heavily on high-stakes exams for student assessment, which have been shown to disadvantage particular groups of students, including women and students with anxiety (Ballen et al., 2017; Matz et al., 2017; Harris et al., 2019). The emphasis STEM courses place on high-stakes exams likely exacerbated issues with test-taking and proctoring that were mentioned by students in this study. In sum, these challenges result from ableism in academia and STEM, and although we did not specifically ask students about ableism in STEM, these themes were echoed by some students in this study.

What immediate changes can be made to make online course work more accessible for students with disabilities, both in the online courses during the pandemic and afterward? First, instructors and DRCs can work to reduce the need for students with disabilities to advocate for accommodations. Students with disabilities can experience challenges with self-advocacy, specifically as it relates to revealing their need for accommodations to their instructors and working with the DRC (Lynch and Gussel, 1996; Brinckerhoff, 1994; Test et al., 2005; Pfeifer et al., 2020, 2021). To help alleviate this burden, instructors can survey students during the term to assess what aspects of their online courses are presenting challenges to students and work with the students and DRC to develop proper accommodations. Additionally, administrators can send explicit instructions to instructors teaching online courses about the importance of adhering to students' previously established accommodations. This type of communication will hopefully help remind instructors to ensure that students with disabilities are accommodated online. We also recommend that departments educate instructors on how some of their instructional decisions may disproportionately negatively impact students with disabilities in online settings, such as the overwhelming detrimental effects of using test proctoring systems. Instead of focusing on how to maintain test integrity of high-stakes exams with test proctoring, departments can advocate for instructors to develop more authentic assessments. Very few jobs expect employees to take timed, proctored tests, so shifting to open-book assessments better mimics the skills that graduates will need. Alternatively, departments can encourage instructors to shift from a few high-stakes assessments that are proctored to many low-stakes assessments that are not proctored, or even to adopt an "ungrading" philosophy (Blum and Kohn, 2020) that focuses attention on learning, rather than a specific grade. Not only can these strategies be beneficial for students with disabilities, but they may help other marginalized groups. For example, recent evidence suggests that high-stakes testing can further exacerbate gender gaps between students (e.g., Eddy et al., 2014; Wright et al., 2016; Ballen et al., 2017). Moreover, as instructors are being provided with more notice that they will be teaching STEM courses online, they can use universal design for learning as they develop their courses. Universal design for learning is a framework focused on designing accessible learning environments in which the needs of all learners are considered without specialized adaptation or accommodation (Rose and Meyer, 2002; Burgstahler and Cory, 2010; Street et al., 2012). An example of applying the universal design for learning framework in online instruction could be ensuring that synchronous class sessions are recorded, captioned, and posted for all students to access. Finally, while our research highlights that COVID-19 created new challenges for individuals with disabilities, it is worth noting that the pandemic has forced individuals to reconsider some of the ableist societal norms and assumptions related to working and schooling. For example, individuals with disabilities, such as those with chronic health conditions, may have previously requested to work remotely, but it was perhaps against the policy of the institution to do so. However, COVID-19 normalized "telework" or working from home (Schur et al., 2020). Overall, ensuring that students with disabilities are able to access education and engage in learning during unique yet enduring circumstances is critical as we continue to aim to create a more diverse

and inclusive scientific community (Intemann, 2009; PCAST, 2012).

Limitations

We have previously argued that there are three primary stakeholders in disability advocacy at colleges and universities: students, the DRC, and instructors (Gin *et al.*, 2020). It is important to note that this work features the voices of students and does not reflect the thoughts or opinions of the DRCs or instructors of STEM courses. We acknowledge that aspects of what students with disabilities required may have been in conflict with what DRCs and instructors were able to provide to students given their own challenges with the pandemic. As such, we do not advocate for what should have happened or place blame on individuals, but we hope that this work draws attention to areas that can be addressed in preparing for any online course or future time when in-person course work would need to be rapidly transitioned to another platform.

Our recruitment methods asked DRC staff to pass the request on to all students registered with the DRC, and students had to ultimately sign up to participate in our interviews, so there is a sampling bias in our study. We limited our recruitment to large-enrollment institutions, because most of these institutions went online and they had large numbers of students enrolled, so they were likely to have a large number of students registered with the DRC. We tried to recruit from all large-enrollment institutions, but only seven institutions agreed to participate. Although we did recruit a national sample of students with disabilities through these seven large-enrollment institutions, we acknowledge that this work is missing the voices of students from smaller institutions, such as community colleges and private colleges. It is likely that students who attended community colleges have had even less support, because these institutions typically have fewer resources and support staff (Schinske *et al.*, 2017), whereas students from small private colleges may have had more resources and more personalized responses during the pandemic. More research needs to be done on the student experience during the COVID-19 pandemic at these other institutions. Although we saw commonalities among the student experiences and did not see any clear patterns that were specific to an institution, we encourage caution in generalizing our results, because they are based on the experiences of students from seven institutions.

Another limitation of our study is that we are unable to determine how representative our sample is in terms of types of specific disabilities due to the lack of available data on students with specific disabilities collected at the national level. The National Science Foundation report *Women, Minorities, and Persons with Disabilities in Science and Engineering* only presents aggregated data on individuals with disabilities but does not provide a breakdown by disability type (National Science Foundation, 2019). Moreover, our sample is primarily composed of white women. As a result, we caution against the generalizability beyond the specific context of our sample. We also realize that the lived experience of individuals with disabilities is a result of many identities (gender, race/ethnicity, etc.) and their intersections (Annamma *et al.*, 2013; Sins Invalid, 2019); however, given the lack of diversity in this sample and small sample sizes for other identity markers, we felt we were unable to adequately address intersectional components of participant identities with disabilities. We recommend that future research should make intentional efforts to recruit students with disabilities through an intersectional lens. Finally, this study only examined student perceptions of their experiences during the pandemic and not their performances in courses. Based on the challenges with their accommodations, we would predict that their course performances were negatively affected, but this is an area for future research.

CONCLUSION

In this study, we examined the experiences of students with disabilities enrolled in undergraduate STEM courses during the transition to online instruction due to the COVID-19 pandemic. We found that students with disabilities were often unable to access the accommodations that they had used in in-person courses, such as reduced-distraction testing environments, additional test time, and note-taking. We also identified that the transition to online instruction resulted in novel challenges for students with disabilities who required additional accommodations, such as closed-captioned video lectures and adapted test proctoring. Finally, this study uncovered barriers that prevented students from effectively and efficiently receiving needed accommodations for their online instruction during the COVID-19 pandemic. Instructors making determinations about what they perceived to be appropriate accommodations, the lack of proactive DRC involvement in identifying necessary accommodations, and the increased need for self-advocacy prevented students from receiving accommodations that would have likely improved their experiences in STEM courses during this unprecedented time.

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