# Challenges and Opportunities for Students with Disabilities in Evolving Learning Environments: Active Learning, Online Instruction, and Undergraduate Research

by

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ABSTRACT

Innovations in undergraduate education have increased the prevalence of active learning courses, online education, and student engagement in the high-impact practice of undergraduate research, however it is unknown whether students with disabilities are able to engage in these innovative learning environments to the same extent that they are able to engage in more traditional learning environments. Universities, disability resource centers, and instructors are mandated to provide accommodations to students with disabilities for the purposes of prohibiting discrimination and ensuring equal access to opportunities for individuals with disabilities. Are accommodations being adapted and created for these new types of learning environments? This dissertation reports findings from four studies about the experiences of students with disabilities in these three learning environments, specifically examining the challenges students with disabilities encounter and the emerging recommendations for more effective accommodations. I find that students with disabilities experience challenges in each of these learning environments and that the current suite of accommodations are not sufficient for students with disabilities. I argue that institutions need to consider modifying student accommodations and the process for obtaining them to better support students with disabilities in these evolving learning environments. I also provide recommendations for the ways in which undergraduate science education can be made more accessible and inclusive of students with disabilities.

# DEDICATION

I dedicate this to everyone who has supported me throughout many of life's journeys. To my family, especially my mom, dad, and sister-in-law for your unwavering love and support through the highs and the lows of life. To Dennis and Wendy Frey who inspired me to pursue my dreams and never look back. And finally, to my mentors, colleagues, students, and friends who have challenged me and have encouraged me to think deeply about the importance of access to higher education.

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# CHAPTER 1

## Introduction

This dissertation is focused on identifying ways to make undergraduate science education more inclusive for students with disabilities. This introductory chapter will first describe what is considered a disability, the evidence for students with disabilities being underrepresented in science, and the legal mandates to adequately accommodate students with disabilities. Then it will highlight how higher education has changed in dramatic ways since the passing of the some of the legislature that ensures equal opportunities for students with disabilities, which has the potential for creating novel challenges for students with disabilities. Finally, it will present the theoretical frameworks that can be used to explore the experiences of students with disabilities: the medical model of disability, the social model of disability, and the community wealth framework.

Individuals with disabilities represent roughly 26% of the US population (Centers for Disease Control and Prevention, 2018). Notably, there is some variation in how "disability" is defined and how it is operationalized. For example, the Americans with Disabilities Act (ADA) of 1990 considers disability to be "a physical or mental impairment that substantially limits one or more major life activities, a record of such impairment, or being regarded as having such an impairment" (Americans with Disabilities Act of 1990, 1990; ADA Amendments Act of 2008, 2008), which includes "blindness, deafness, autism, bipolar disorder, cancer, cerebral palsy, diabetes, epilepsy, HIV/AIDS, learning or intellectual disabilities, major depression, missing or partial limbs, multiple sclerosis, obsessive compulsive disorder, orthopedic or physical impairments, and post-traumatic stress disorder." Notably, this definition differs from those of national agencies. The US Department of Education's National Center for Education Statistics allows individuals to report any type of disability that includes "blindness, deafness, severe vision or hearing impairment, substantial limitation of mobility, or any other physical, mental, or emotional condition that lasted six months or more" (NCES, 2015), while the National Science Foundation (NSF) asks survey participants, "What is the usual degree of difficulty you have with (specific tasks involving seeing, hearing, walking, and lifting)?" where individuals respond to each of them on a five-point scale of "none" to "unable to do." According to the NSF, having a disability is defined as having at least moderate difficulty in performing one or more of these tasks (National Science Foundation, 2002). These different definitions make it challenging to directly compare who identifies as having a disability, but part of the challenge of defining disability is the inherent variability in condition and severity that can change over time.

Individuals with disabilities are underrepresented in postsecondary science education, despite the projected job growth in science, technology, engineering, and math (STEM) professions which makes broadening representation from diverse backgrounds essential (Fayer et al., 2017; Olson & Riordan, 2012). Further, the lack of individuals with disabilities in STEM means that their unique perspectives are often missing from scientific discourse (Intemann, 2009; Yosso, 2005). While individuals with disabilities are estimated to make up about 26% of the US population, they represent 18% of individuals pursuing an undergraduate degree in the life sciences and only about 10% of those who graduate college with a degree in the life sciences (Centers for Disease Control and Prevention, 2018; National Science Foundation, 2016). Despite this, there has been little empirical work on the experiences of students with disabilities in undergraduate science education to determine why students with disabilities choose to leave the sciences and pursue degrees elsewhere. Therefore, there is a critical need to identify the barriers and affordances that affect the persistence of undergraduates in STEM with disabilities. Without foundational research, we cannot develop evidence-based interventions to increase retention, a key step to diversifying the scientific community.

Students with disabilities in higher education have been legally protected in the United States since 1973. Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 (Americans with Disabilities Act of 1990, 1990; Section 504 of the Rehabilitation Act, 1973) prohibit disability discrimination for entities that receive federal financial assistance, such as funding from the National Science Foundation or the National Institute of Health (Eckes & Ochoa, 2005; Madaus, 2005). In addition, since colleges and universities are classified as such entities, it mandates that they make reasonable accommodations and modifications to learning environments, as long as they do not fundamentally alter a particular program, to provide equal opportunities to students with disabilities (Feldblum, 1996; Madaus, 2011). These accommodations and services are typically provided by a specific office on campus that supports students with disabilities, such as a Disability Resource Center (DRC), where students and DRC coordinators can choose from a suite of accommodations and determine what is most appropriate for a given student's needs and a given course. The standard suite of accommodations provided for students can include, but is not limited to, interpreters, transcriptionists, note-taking services, closed-captioning, extended and reduced-distraction testing, and flexible attendance and assignment deadlines.

However, although DRCs are now almost standard entities on college campuses, undergraduate science education has changed dramatically since the passage of Section 504 and the ADA (Ali, 2019; Brubacher & Rudy, 2017). Recent national recommendations have promoted the transition from teacher-centered to student-centered, **active learning**, which changes the role of the student from passive listener to active contributor (American Association for the Advancement of Science, 2011; Freeman et al., 2014). Additionally, the advent of technology has changed the ways in which students engage with material in class, from answering questions via a personal handheld clicker device to using an online platform for discussions outside of class (Burns, 2017; Misseyanni et al., 2018; Smith et al., 2013). Moreover, national calls have advised science undergraduate students to engage in high-impact practices, or teaching and learning practices that have been widely tested and have been shown to be beneficial for college students from many backgrounds, such as **undergraduate research** (Kuh, 2008; Sandeen, 2012). Finally, the increase in the number of **online courses** and online degree programs has changed what undergraduate science curricula look like. This was further exacerbated by the COVID-19 pandemic, which resulted in nearly all colleges and universities rapidly transitioning their in-person instruction to an online format during the Spring 2020 term (Aguilera-Hermida, 2020; Baker et al., 2020; Hartocollis, 2020).

Thus, the vision of a college classroom from 1973 and 1990, when these key pieces of legislation were introduced is now, compared to a college classroom in the 21st century, is very different. The standard accommodations, such as note-taking services or extended time on exams, work well in a classroom where all students are experiencing the same pedagogical practice such as an instructor lecturing or there are only three exams in the course. However, if students are working in different groups to solve a set of problems during class, what should a notetaker capture? Should the notetaker be in the same group with every student that needs a notetaker as an accommodation? How do students engaged in undergraduate research for credit receive accommodations? To what extent can students enrolled in a fully online course experience a reduced noise testing environment? It is unclear how the changes to college science learning have impacted the experiences of students with disabilities given that there have not been changes in legislation and may not be concomitant changes in accommodations. Despite the abundance of literature on these innovative teaching strategies, there has been a dearth of research on the specific experiences of students with disabilities.

It is important to note that there are three key stakeholders and entities that are responsible for ensuring that students with disabilities are properly accommodated in an undergraduate science curriculum: Disability Resource Centers, instructors, and students. **Disability Resource Center** staff members have an array of experience working with both students and instructors and can describe how the process of accommodating students works within a university setting at-scale. DRCs interface with both instructors and students to determine what accommodations are appropriate for students given a particular learning context. **Instructors** provide knowledge of the given learning environment where they are teaching, the types of activities they engage students in with, and knowledge of the subject matter which they are teaching. They interact with students in their courses as well as receive communication from the DRC to ensure that all students in their courses are accommodated per federal mandates. Finally, **students with disabilities** can provide first-hand accounts about their experiences as they navigate these evolving learning environments, interacting with both instructors and DRCs. Ultimately, to truly understand the barriers and affordances of these evolving learning environments and better support students with disabilities, it is crucial that the perspectives from multiple stakeholders are considered.

In this work, I am invoking three sets of theoretical frameworks. The **medical model of disability** includes the factual information and experience of living with different physical, sensory, cognitive, or affective functions than the majority of the population (Brisenden, 1986). This approach considers disability to be an impairment of the individual and the limitations that result from their impairment. The **social model of disability** considers the experiences of facing attitudes, structures, bias, stigma, and discrimination based on one's structural or functional atypicality (Oliver, 1996, 2013; Shakespeare, 2006). This model emerged during the disability rights movement to consider disability to be socially constructed as a result of biases and discrimination within society. The approach considers disability to be a social construct that results in opportunities being taken away from an individual based on their *impairment* due to the attitudes and structures of society which then results in *disability*. For example, an individual who is blind (*impairment*) may not be able to read signs because they are not also written in braille (*disability*). I am using a combination of both the medical model and the social model because there are aspects of disabilities that do prevent students from engaging in certain scientific practices, but the way university classrooms are set up can also be an unnecessary barrier for students with disabilities.

In addition to each of these models of disability, my dissertation also considers how students with disabilities may uniquely experience and contribute to each evolving learning environment. As such, I use the **community wealth framework**, originally developed from critical race theory for communities of color, which suggests that there are an array of knowledges, skills, abilities, and contacts possessed by underrepresented populations survive and resist forms of oppression (Yosso, 2005). Specifically, the community cultural wealth framework includes components of capital that are unique to a particular underrepresented group of individuals, such as individuals with disabilities. In this dissertation, I argue that none of these models is sufficient to describe the experience of a student with a disability, but rather, each of these models needs to be considered in conjunction to fully describe the experience (**Figure 1-1**). By capturing the experience of individuals with disabilities from each of these approaches, I argue that this holistic experience can help inform future research, policy, and interventions for individuals with disabilities.

## Goals of Dissertation

For my dissertation, I characterize the experiences of students with disabilities in novel and evolving undergraduate science learning environments, which includes active learning science classrooms, undergraduate research experiences, and online science courses. In each of these, I use the medical model perspective of disability and the social model perspective of disability to determine the ways that DRC's, instructors, and students describe the experiences of students with disabilities in evolving learning environments. My dissertation consists of four studies. Below I describe each study and how it relates to my overall dissertation.

Chapter 2 focuses on the experiences of students with disabilities in active learning science courses. In this chapter, I begin by providing a review of the history of providing accommodations to students with disabilities in higher education. I then present the context of active learning science courses as an evolving learning environment that may introduce challenges for students with disabilities. By conducting interviews with 37 Disability Resource Center directors, I documented the challenges that they perceive active learning presents for students with disabilities, the extent to which accommodations alleviate such challenges (if at all), and recommendations they have for making active learning environments more inclusive for students with disabilities. I also propose a model that describes the retroactive process of accommodation for students with disabilities in these learning environments.

Chapter 3 explores the ways in which students with disabilities are accommodated in online science courses, particularly after the rapid transition to online learning as a result of the COVID-19 pandemic. I conducted interviews with 66 undergraduate STEM students with disabilities who were taking science courses that transitioned online during the Spring 2020. In these interviews, I explored 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. Overall, I found that the online learning environment presented novel challenges for students, but students were unable to access their previously established, in-person accommodations as a result of the transition. Moreover, students reported that instructors made decisions about what was and was not appropriate in terms of accommodations, and DRCs did not provide adequate communication about what students could and should have received following the transition to online learning.

Chapter 4 is a follow-up study to the previous chapter and reports the experiences of students with disabilities in online science learning environments one year following the transition to online instruction. I built upon my interviews to conduct a survey study of students with disabilities who were registered with the DRC and taking online science courses during the Spring 2021 semester. I found that more than half of students with disabilities reported not being properly accommodated which was reported more frequently by students who experienced new challenges related to online learning. Based on this study and the previous study, this chapter also provides recommendations for making online science learning environments more inclusive for students with disabilities.

Chapter 5 examines students with disabilities who are participating in undergraduate research experiences. In the first part of this chapter, I conducted a national survey of 1,262 life science undergraduate researchers to determine that only around 12% of undergraduate researchers in the life sciences identify as having a disability. In the second part of this chapter, I conducted semi-structured interviews with 20 students from this sample of undergraduate researchers. I found that undergraduate researchers with disabilities experience unique and distinctive challenges in their research experiences as well as unique solutions to the challenges that they encounter. Moreover, I also find that undergraduate researchers with disabilities experience unique benefits from participating in research and also provide unique contributions to the scientific research community.

Chapter 6 is the final chapter of my dissertation and includes recommendations for making evolving science learning environments more inclusive for undergraduate students with disabilities. It also provides suggestions for future work based on the findings from this work, specifically focusing on other stakeholders who play integral roles in appropriately accommodating students.

## Tables and Figures

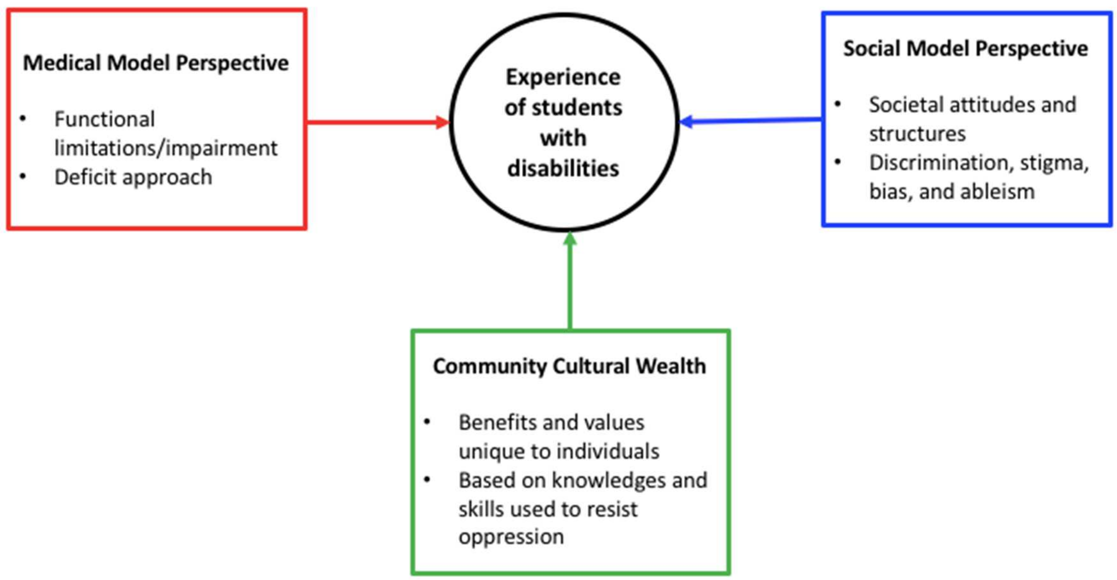


**Figure 1-1. Models Used to Describe the Experiences of Students with Disabilities.** Medical model of disability (Brisenden, 1986), social model of disability (Oliver, 1996, 2013; Shakespeare, 2006), and community cultural wealth (Yosso, 2005).

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# CHAPTER 2

## IS ACTIVE LEARNING ACCESSIBLE? EXPLORING THE PROCESS OF PROVIDING ACCOMMODATIONS TO STUDENTS WITH DISABILITIES


**Abstract**

On average, active learning improves student achievement in college science courses, yet may present challenges for students with disabilities. I review the history of accommodating students with disabilities in higher education, highlight how active learning may not always be inclusive of college science students with disabilities, and articulate three questions that could guide research as the science community strives to create more inclusive environments for undergraduates with disabilities: (A) To what extent do stakeholders (Disability Resource Center (DRC) directors, instructors, and students) perceive that students with disabilities encounter challenges in active learning? (B) What accommodations, if any, do stakeholders perceive are being provided for students with disabilities in active learning? and (C) What steps can stakeholders take to enhance the experiences of students with disabilities in active learning? To provide an example of how data can be collected to begin to answer these questions, I interviewed 37 DRC directors and reported their perceived challenges that students with disabilities experience in active learning and the extent to which accommodations are used to alleviate challenges. I conclude with a suite of recommendations to create more inclusive active learning college science classes for students with disabilities.

## Introduction

National recommendations have encouraged college science instructors to shift their teaching from traditional lecture to active learning (American Association for the Advancement of Science, 2011). In active learning classes, students engage in constructing their knowledge as opposed to passively listening to an instructor for an entire class session. Active learning practices, on average, have a positive impact on student learning (Freeman et al., 2014), and there is some evidence that active learning may decrease achievement gaps between students in minority and majority groups (Ballen et al., 2017; Eddy & Hogan, 2014; Haak et al., 2011; Theobald et al., 2020). As such, active learning may be assumed to be more equitable than traditional lecture and it has even been considered an inclusive teaching practice (Dewsbury & Brame, 2019).

However, active learning significantly changes the classroom structure in ways that could create challenges for some students, potentially introducing inequities that are not present in traditional lecture courses. Previous research has indicated that how active learning practices are implemented, particularly with regard to student participation and social interactions, can create challenges for groups of students who are typically underserved or underrepresented in science including women, students with anxiety, and LGBTQ+ students (Ballen et al., 2019; Cooper, Downing, et al., 2018; Cooper & Brownell, 2016; Downing et al., In press; Eddy et al., 2015; England et al., 2017, 2019). We propose that students with disabilities may be an additional underrepresented group that faces unique challenges in active learning (Braun et al., 2018; Gonzales, 2016; Hall, 2017; Moon et al., 2012). We assert that while the transformation of college science courses into active learning courses is critical in order to enhance student learning overall, it has the potential to create additional barriers and challenges for students with disabilities. While certain institutional programs are mandated to support students with disabilities, such as Disability Resource Centers, the extent to which these programs have evolved to accommodate possible challenges that active learning presents for students with disabilities is unclear.

We review the history of accommodating students with disabilities in higher education and highlight how active learning may not be an inclusive teaching approach for college students with disabilities without modifications to the current accommodations and support. We present three guiding questions to consider as we strive toward creating more inclusive college science active learning environments for students with disabilities. We argue that these questions need to be addressed from the perspectives of students with disabilities, active learning instructors, and directors of Disability Resource Centers (DRCs). To demonstrate that these guiding questions could be useful in developing more inclusive undergraduate science education, we interviewed directors of DRCs from 37 institutions of higher education across the United States about how they are accommodating students with disabilities in active learning science classrooms and the challenges associated with accommodating students in active learning environments. Finally, we present a suite of recommendations for instructors and DRC staff who aim to create more inclusive active learning college science classes for students with disabilities.

**Who are students with disabilities?**

The social model of disability, that emerged during the disabilities rights movement of the 1970's and 1980's, argues that disability is a social construct; an individual may have a functional *limitation*, or physical, mental, or sensory *impairment*, but what makes that individual have a *disability* is that opportunities are taken away due to the attitudes and structures of society (Oliver, 1996, 2013; Shakespeare, 2006). For example, an individual with muscular dystrophy (*impairment*) may be unable to enter a building with their wheelchair if the building does not have a ramp or accessible entrance (*disability*).

What is considered proper discourse regarding disabilities has changed in the last few decades. Describing someone as "handicapped" or "differently-abled" is outdated and can be offensive to some people; this language has predominately been replaced with person-first language (e.g., "student with a disability"). Person-first language[1] places the emphasis on the individual, not the disability, which implies that the individual is foremost a person who happens to have a disability (NCDJ, 2018). Notably, the American Psychological Association (APA) considers person-first language a general principle of bias-free language for talking about disability with inclusivity and respect (American Psychological Association, 2020). We have chosen to use person-first language to describe students with disabilities in this essay because it emphasizes that the disability does not define the person.

[1] We acknowledge that there has been some criticism of the use of person-first language, particularly from the autistic community (e.g. (Kenny et al., 2016), deaf community (e.g. Lum, 2010), and blind community (e.g. Vaughan, 2009). While we respect and recognize these concerns, we have chosen to use person-first language (e.g. student with a disability) in this essay because we feel as though it is most generalizable to all students with disabilities.

There are a variety of definitions of “disability” used in different contexts. The Americans with Disabilities Act (ADA) of 1990 defines disability as “a physical or mental impairment that substantially limits one or more major life activities, a record of such impairment, or being regarded as having such an impairment” (ADA, 1990, 2008). The US Department of Education’s National Center for Education Statistics operationalizes disability to include those who report any type of disability related to “blindness, deafness, severe vision or hearing impairment, substantial limitation of mobility, or any other physical, mental, or emotional condition that lasted six months or more” (NCES, 2015). For the purposes of this essay, we draw from both of these definitions and focus on disabilities that would typically be serviced by university Disability Resource Centers. These include, but are not limited to, learning disabilities (e.g. autism, dyslexia), physical disabilities (e.g. cerebral palsy, spina bifida), chronic health conditions (e.g. cancer, diabetes), vision loss, hearing loss, and mental health and psychological disabilities (e.g. anxiety, depression).

**History of accommodations for students with disabilities**

Students with disabilities have been recognized as an at-risk population in higher education and have been legally protected in the United States since 1973. Section 504 of the Rehabilitation Act of 1973 (Section 504, 1973) and the Americans with Disabilities Act of 1990 (ADA, 1990) prohibit discrimination on the basis of disability in programs or activities that receive federal financial assistance (Eckes & Ochoa, 2005; Madaus, 2005). Specifically, Section 504 requires postsecondary institutions, both public and private, that receive federal aid or funding (e.g. NSF, NIH, FASFA) to consider applications from qualified students with disabilities. It also requires colleges and universities to make modifications to courses through the use of auxiliary aids and services (e.g. interpreters, note takers, transcriptionists) for students with disabilities (Feldblum, 1996; Madaus, 2011). Similarly, the ADA requires that colleges and universities make course modifications to accommodate students with disabilities, as long as such modifications do not fundamentally alter academic programs in such a way that it changes the nature of the program being offered (ADA, 1990; Meeks & Jain, 2015).

The passage of this legislation to ensure the rights of students with disabilities contributed to the increase in the number of students with disabilities in higher education, and in turn, the number of programs designed to specifically serve students with disabilities has also grown (Madaus, 1996). While these disability service programs can vary widely, the most common version is a Disability Resource Center[2], which describes an office on a university campus that provides academic and social services for students with disabilities and diagnosed medical conditions (ADA, 1990; Section 504, 1973). On many campuses, DRCs are the units responsible for providing college students with academic accommodations in their courses and keeping the institution in compliance with the federal mandates.

**Challenges in accommodating students with disabilities in higher education**

[2] Disability Resource Center (DRC) is the general term to describe offices on college campuses to support students with disabilities. We acknowledge that some institutions have other names to describe these offices, such as Disability Support Services, Accessibility Services, Student Access Centers, and Accommodation Resource Offices. For the purpose of this essay, we have chosen to use the term DRC because it is commonly used to describe these types of offices on many college campuses.

Despite the legal requirements for institutions to support students with disabilities and the increased number of DRCs serving students, there is a myriad of challenges that hinder students with disabilities from accessing the appropriate accommodations in the college classroom (Dowrick et al., 2005; Marshak et al., 2010; West, 1993). Studies have demonstrated that students with disabilities sometimes are unaware of the presence of the DRC on their campus or are uncertain of the range of services that DRCs provide (Dowrick et al., 2005; Marshak et al., 2010). Additionally, even if a student knows that their institution's DRC exists, they may have trouble utilizing their services because of the amount of time and effort it can take to access such services. Students with disabilities need to be their own advocate in college because it is solely their responsibility to recognize when they need an accommodation (Brinkerhoff et al., 2002; Eckes & Ochoa, 2005). This is in stark contrast to many students' experiences in high school where the student's family as well as school officials and teachers are primarily responsible for recognizing a student's disability and taking action to provide appropriate accommodations (Hadley, 2007; Janiga & Costenbader, 2002; Madaus, 2005; Smith et al., 2002). Further, there is often a stigma associated with having a disability; individuals with disabilities are often discriminated against in society and students may be reluctant to disclose their disability in the context of college (Fine & Asch, 1988; Meredith, 2014; Trammell, 2009). Students may fear being singled out by an instructor for their disability, which may encourage them to conceal their disability if it is possible (Getzel & Thoma, 2008; Marshak et al., 2010; Ruban et al., 2003). Finally, if students perceive DRC accommodations to be ineffective or if they have previously had a negative experience with the DRC, they may avoid using them in the future; a survey of students registered with disability services at community and technical colleges found that students are most likely to use accommodations when they view them as effective for improving their independence (Kurth & Mellard, 2006). Given that students must know to advocate for themselves, learn about and seek services from their institution's DRC, and identify useful accommodations, it is unsurprising that navigating the accommodations process can be physically, mentally, and emotionally taxing for students with disabilities (Hong, 2015).

In addition to engaging directly with the DRC, students with disabilities often need to discuss their disability and their requested accommodations with their instructors. These interactions can be negative and it has been reported that instructors can have lower academic expectations for students with disabilities compared to students who do not have disabilities (Hong, 2015; Marshak et al., 2010). The most commonly cited issue by students with disabilities in the Florida College System was the attitudes of faculty and staff who were not familiar with disability concerns (Florida College System, 2009). Instructors have also reported challenges in working with and accommodating students with disabilities in their courses; challenges were most likely to be cited by instructors with less teaching experience and instructors with less experience working with students with disabilities (Johnson, 2006). In an interview study of five faculty members who have taught students with disabilities at their institution, these instructors discussed a lack of professional support and guidance for how to work with students with disabilities, procedural issues with accommodating students (e.g. not being informed of the nature of a student's particular disability yet wanting to maintain student confidentiality), and challenges with specific classroom contexts and teaching practices, such as accommodating the needs of students with disabilities in a large course with limited class time (Love et al., 2014). There are no requirements for college instructors to possess the knowledge or skill sets to provide instructional accommodations for students with disabilities (Eckes & Ochoa, 2005; Rule et al., 2009), which often means that instructors are ill-equipped to handle these situations.

**Students with disabilities are highly underrepresented in science and may face unique challenges**

Individuals with disabilities are highly underrepresented in postsecondary science education. The American Community Survey estimated the percent of people with disabilities in the population in 2016 to be 12.8% (Erickson et al., 2017). However, individuals with disabilities make up only about 5% of students enrolled in undergraduate STEM education (National Science Foundation, 2016).

There has been limited research conducted on the experiences of science students with disabilities in higher education, although a few studies provide insight into the challenges, issues, and barriers that college science students with disabilities may face. We suspect that challenges might contribute to the underrepresentation of students with disabilities in science. For example, science disciplines may be particularly unwilling to accommodate students with disabilities; one study showed that regardless of the type of postsecondary institution (e.g. research-intensive, master's granting), science, technology, engineering, and math (STEM) majors with disabilities received fewer accommodations than non-STEM majors with disabilities (Lee, 2011). Additionally, students with disabilities may interact with science instructors who doubt their ability to succeed and may experience a lack of adequate accommodations for their science coursework (Dunn et al., 2012). There are documented academic performance differences between undergraduates studying science with disabilities and those without disabilities, likely because of the unique barriers that science students with disabilities face regarding securing proper accommodations. For example, in a study of students at a single institution, students with disabilities earned lower course grades on average in introductory chemistry compared to students without disabilities despite their comparable coursework in high school, SAT/ACT scores, and the ability to meet the same university admissions criteria (Street et al., 2012). In addition, a focus group study of twenty college students with disabilities found that students in science have difficulties in evaluative situations when they feel like they are being judged based on their disability, such as lab coursework (Jenson et al., 2011). In sum, although there are only a few studies on students with disabilities in college science, the extant research suggests that science may present specific challenges for students with disabilities.

**Are active learning science courses inclusive of students with disabilities?**

Active learning is an umbrella used term to describe a variety of different instructional practices that increase students' engagement in the process of learning (Bonwell & Eison, 1991; Freeman et al., 2014; Prince, 2004). Often, researchers and instructors use the term active learning in contrast to lecture-based instruction where students passively absorb information by listening to an instructor for an entire class period. There are many different ways that active learning can be implemented, including asking students to answer questions in response to the instructor either one-on-one or in front of the whole class (e.g., cold call, random call), having students interact to solve problems (e.g., pair discussions, groupwork), and using technology (e.g., personal response devices, watching videos for homework in preparation for class). For the purpose of this essay, we define active learning as any instruction that is not lecturing for the full class period.

Active learning has been championed as an effective teaching practice that, on average, results in students learning more and failing less in college science courses (Freeman et al., 2014). However, active learning has also been shown to present challenges for some groups of students (Cooper, Downing, et al., 2018; Cooper & Brownell, 2016; Downing et al., In press; Eddy et al., 2015; Eddy & Brownell, 2016; Eddy & Hogan, 2014; England et al., 2017, 2019). It is currently unknown to what extent active learning presents challenges to students with disabilities, although we hypothesize that it does. Further, it is unknown to what extent DRCs and instructors are adapting to accommodate students with disabilities in active learning classrooms.

In order to move toward a more inclusive scientific community for undergraduates with disabilities, we present three guiding questions:

*(A) To what extent do key stakeholders (DRC directors, instructors, students) perceive that students with disabilities encounter challenges in active learning science courses?*

*(B) What accommodations, if any, do key stakeholders perceive are currently being provided for students with disabilities in active learning science courses?*

*(C) What steps can key stakeholders take to enhance the experiences of students with disabilities in active learning science courses?*

By working to answer these questions from the three distinct perspectives and triangulating the data, we argue that the science community will gain a deeper understanding of the challenges that undergraduates with disabilities face in active learning classes and the resources that are and are not available to them. It is imperative that we include the opinions of a diversity of students with disabilities who experience challenges in active learning first-hand because their unique experiences need to be documented. However, students may not be aware of policies that are set in place by DRCs, how DRCs interact with instructors, or instructor needs that may conflict with certain accommodations. Thus, it will also be important to consider the perspectives of college science instructors who will likely provide knowledge about how accommodations can be successfully integrated into active learning classrooms and the challenges that they face in interacting with the DRC and students with disabilities. Finally, DRCs provide accommodations to students at scale and can speak to general trends that occur for hundreds of students over multiple years. While there are other stakeholders that we may want to consider (e.g., families of students with disabilities, university administrators), we argue that DRCs, instructors, and students with disabilities have the most experience with these issues and their perspectives are the most relevant.

**Furthering our understanding of the relationship between students with disabilities and active learning**

The intention of this essay is twofold; both to bring attention to the importance of considering the experiences of students with disabilities in active learning courses and to demonstrate how these guiding questions could provide a foundation for helping the science education research community understand how to create inclusive active learning classrooms for students with disabilities. Below we present data collected from one of the stakeholders- DRC directors- to begin to address these questions. We decided to start with DRC directors as opposed to students because DRC directors have interacted with hundreds to thousands of students with disabilities and will have a broad sense for challenges that have repeatedly arisen.

## Methods

I interviewed 37 directors of university DRCs across the United States. Specifically, we attempted to recruit directors from all large-enrollment institutions (>10,000 students) based on the Carnegie Classification of Institutions of Higher Education (n = 302). We intentionally targeted large-enrollment institutions because these institutions typically serve a large number of students and often have a specific office on campus for students with disabilities (Madaus, 1996). Of the 302 large-enrollment institutions, we were able to find the contact information for the directors of 288 (95%) DRCs and sent them a personalized email in Fall 2019 requesting to interview them about their accommodations for college students with disabilities. We contacted each director a second time via follow-up email if they did not respond to our initial email. Of the 288 directors that we contacted, 234 (81%) directors did not respond to either email and 20 (7%) directors declined to participate in an interview. We hypothesize that some DRC directors chose not to participate in the interview due to scheduling concerns with the end of the semester (e.g., final exam proctoring) or perhaps because there was no monetary incentive to participate. In total, DRC directors from 37 (13%) institutions agreed to participate in an interview. The DRC directors whom we interviewed represent 17 R1 (very high research activity) institutions, 13 R2 (high research activity) institutions, six Master's granting institutions, and one Bachelor's granting institution. Seven were institutions located in the Northeast, seven in the South, 14 in the Midwest, and nine in the West. Three institutions were private and 34 institutions were public. A full list of anonymized institutions whose DRC directors participated in an interview is listed in **Appendix A** and includes the type of institution, the location, and whether it is public or private.

We conducted semi-structured interviews with each of the DRC directors exploring their familiarity with active learning, the processes for providing academic accommodations for students with disabilities in active learning science courses, and their perceptions of the challenges associated with providing accommodations for students with disabilities in active learning science classes (see **Appendix A** for a copy of the interview script). Interviews were audio-recorded and transcribed for analysis. We used inductive coding to identify themes from the interviews (e.g., ways in which DRCs accommodate students with disabilities in active learning classrooms) and deductive coding to quantify director-reported knowledge or actions regarding a particular topic (e.g., the number of DRC directors who are familiar with the term active learning) (Creswell, 1994; Thomas, 2003). Two researchers each individually reviewed a different set of 10 interviews independently and took detailed analytic notes to identify initial themes (Birks & Mills, 2015). The two then came together to discuss themes and developed a codebook describing each theme. Eight interviews (22%) were independently coded by both authors using the finalized codebook. The researchers then compared their codes and their Cohen's $\kappa$ interrater score for these eight interviews was at an acceptable level ($\kappa = 0.89$) (Landis & Koch, 1977). One researcher (F.G.) then coded the remaining 29 interviews. A copy of the coding rubric can be found in the **Appendix A**.

## Results

**A) To what extent do DRC directors perceive that students with disabilities encounter challenges in active learning science classrooms?**

For DRC directors, the first step of considering that active learning may affect students with disabilities in science is recognizing that instructors use active learning to teach college science courses. While this terminology is becoming increasingly common among the science education community, we were unsure how familiar DRC directors would be with active learning. Given the increasing push for the adoption of active learning in college science courses, it is encouraging that 100% of DRC directors who we interviewed were aware of active learning practices in the classroom, though three directors (8%) were not familiar with the specific term "active learning." The three directors who were not familiar with the term were simply unaware of the terminology but were able to deduce what the term means through their previous experiences with students and instructors. We asked DRC directors to define active learning and they often described active learning as a "student-centered" approach to teaching, engaging students within the classroom in something other than lecture, and described common active learning practices, such as small group work and clicker questions. All directors confirmed that, based on their experience interacting with science students, at least one science instructor at their institution had incorporated at least one active learning practice in their course(s) (e.g., used group work, clicker questions, whole class discussion).

When DRC directors were asked whether they were aware of any challenges that active learning posed for students with disabilities, every director was able to recall at least one instance where active learning presented a challenge for a student with a disability in a college science course. We followed that question by asking DRC directors whether they had specifically encountered students with disabilities who had reported experiencing challenges related to five common aspects of active learning: (1) small group work, or working with a small number of students on a particular task such as a worksheet, (2) clicker questions, or when students use clickers or personal response tools to answer questions that instructors pose to the whole class, usually by posting the question on a PowerPoint slide, (3) cold call or random call, or when instructors call on students who do not volunteer to answer a question in front of the whole class, (4) required participation or providing course points in exchange for engaging in in-class activities, and (5) online activities or activities such as online videos, quizzes, or homework assignments that students engage in for points.

Throughout the interviews, DRC directors highlighted specific examples of how these aspects of active learning could present challenges for students with six distinct types of disabilities: (1) learning disabilities (e.g., autism, dyslexia), (2) mental health/psychological disabilities (e.g., anxiety, depression), (3) physical disabilities (e.g., cerebral palsy, spina bifida), (4) chronic health conditions (cancer, diabetes), (5) vision loss (e.g., blind), and (6) hearing loss (e.g., deaf). We acknowledge that the experiences of individuals are distinct and that the experiences of one person cannot be generalized to everyone with the same disability, nor can the experiences of individuals with a specific disability be generalized to the experiences of individuals with other disabilities. However, in this essay we have chosen to group disabilities into categories based on the type of disability (e.g., physical disability, mental health and psychological disability). We recognize that there is debate about whether disabilities such as autism and ADHD are considered learning disabilities (Budd et al., 2016; Mayes et al., 2000); however, we have chosen to categorize these disabilities as learning disabilities here because we hypothesize that students with autism and ADHD experience academic challenges that are more similar to students with other learning disabilities compared to students with mental health and psychological disabilities in active learning classrooms. This organizational structure of grouping disabilities allows us to identify within-group and between-group similarities and differences.

In total, DRC directors from the 37 institutions highlighted 238 specific instances where students with disabilities whom they met with at their DRC struggled with a particular aspect of active learning in their college science courses. In **Table 2-1**, we present the director-reported struggles that students with different types of disabilities encountered with each aspect of active learning. We also highlight the percent of DRC directors who reported each challenge to show how prevalent some challenges are across institutions. Below we summarize the unique ways in which engaging in certain aspects of active learning may be difficult for students with disabilities. We want to emphasize that these experiences may not be true of all students with a particular type of disability, and that these challenges were reported by DRC directors, not by students with disabilities.

**Small group work:** DRC directors reported that students with different types of disabilities struggle with the nature of small group work. In particular, directors reported that students with both learning disabilities and students with mental health/psychological disabilities tend to have a difficult time engaging with their small groups and sharing their ideas with each other. Some directors mentioned that these interactions can lead to students being worried about being judged. DRC directors also reported that some students have a difficult time with group work based on the physical space setup. For example, some directors described group work in traditional auditorium-style lecture halls being difficult for students who use wheelchairs or other mobility devices, especially if the spaces were designed without the intention of facilitating group work. Directors also discussed how some students who are deaf or hard of hearing can have a difficult time hearing group discussions, particularly in large lecture halls, and that it is often difficult for transcription services to operate within a small group to relay the discussion.

**Clicker questions:** DRC directors described that clicker questions can be challenging for students with disabilities because of how questions are posed to students and because of the process for providing an answer to the question. Specifically, DRC directors described that students with learning disabilities were not always provided with enough time to process the question and subsequently struggled to choose the correct answer. For example, when instructors pose questions on a slide, DRC directors explained that it was sometimes difficult for students with vision loss to either see the questions or see the buttons on the clickers required to respond to the questions. Further, DRC directors highlighted that students with other fine motor disabilities sometimes struggled to physically select or press their intended answer on the device. The stress of not being able to adequately answer a question because of a disability can increase a student's cognitive load, or the amount of information they can hold in their working memory, which could further affect the speed at which they're able to answer (Greer et al., 2013; Heimberg et al., 2010). For example, if a student is stressed that they might hit the wrong button on their clicker, they may have lower mental capacity to engage in the actual question than a student who does not share such concerns.

**Cold call/random call:** Regarding cold call and random call, most director concerns were centered around the timed and evaluative nature of these active learning practices (Cooper, Downing, et al., 2018; Downing et al., In press). Similar to clicker questions, directors reported that students with learning disabilities often are unable to process the cold call question given the time constraints. Some directors described that putting students "on the spot" can be especially problematic for students who may need more time to process information. These students can also struggle with reporting out their answer to the class as a whole due to feeling as though they did not have enough time to formulate their response. For example, students with ADHD may have difficulty focusing during class, and when asked to share out, may not be prepared to share an answer. Similarly, DRC directors described that cold call and random call were also challenging for students with mental health and psychological disabilities, especially social anxiety, when students were asked to share their ideas with the whole class. DRC directors highlighted that these students can feel uncomfortable or overwhelmed speaking publicly in front of their peers and instructors. This echoes the findings of previous studies on students with anxiety in active learning (Cooper, Downing, et al., 2018; Downing et al., In press).

**Required participation:** Many DRC directors described the challenge of students missing class due to their disability. DRC directors explained that for many active learning classes, attendance is often required in order to receive attendance points, participation points, or credit that is tied to in-class assignments. In other cases, it is necessary to work with classmates on projects that span multiple class periods, such as case studies. Often, students' grades are dependent on all students contributing in their group. DRC directors highlighted that these practices can be particularly challenging for students with mental health/psychological disabilities, physical disabilities, and chronic illnesses that may result in the student missing multiple class periods. In many traditional lecture courses, there is no penalty for missing class, but in active learning courses, students are often penalized by missing points and may face social repercussions if they let down groupmates on in-class or out-of-class projects. Notably, students in their groups may not know about a student's disability, which if they knew this information then it could help them understand the absences. However, if the student with the disability is uncomfortable sharing this information (Cooper et al. In press), this can create problems if students are rating each other on their participation.

**Online activities:** Active learning courses often have a significant amount of outside of class work, such as watching videos in preparation for class and completing online homework (Cooper, Ding, et al., 2018; Tucker, 2012). As instructors are flipping their classes using more technology, directors described that these online homework platforms (e.g. Mastering Biology) and other learning management systems (e.g. Blackboard) can be particularly challenging for students with disabilities due to the inaccessibility of these programs and applications. This is particularly concerning for students with vision loss or for deaf and hard of hearing students who may not have access to the content in the appropriate format they need. For example, if a student with vision loss has online homework that includes models and 3D structures, they will likely have trouble completing their online homework assignment. Online content is sometimes inaccessible because the instructor may not provide or does not have the university resources to provide appropriate accommodations such as closed captioning. Even if there are university resources available, it often takes time for content to be closed captioned and this is not helpful for instructors who may procrastinate on posting an assignment. However, resources may also be inaccessible because third-party providers of the online platform have not made their content inclusive (e.g., by not providing closed captioning on videos) or because an adaptive technology used by a student is not compatible with the online program or application. For example, a student who uses a screen reader (a software program that creates audio or braille displays of text on the screen) may not work for particular homework programs or assignments using a specific third-party provider.

**(B) What accommodations, if any, do DRC directors perceive are currently being provided for students with disabilities in active learning science classrooms?**

Given the challenges that active learning poses for students with disabilities, documenting what active learning-related accommodations are being offered to students is a key step in promoting inclusive college science classrooms for students with disabilities. Given the role of DRCs in helping instructors provide accommodations, they would know what the general recommendations would be and if there are any specific policies.

**Proactive vs. Retroactive accommodations.** Students with disabilities can either seek classroom accommodations proactively, before the course begins, or retroactively, after they have attended the course and engaged in active learning. For students with disabilities who know to seek accommodations, the general process for receiving accommodations for a traditional lecture course is relatively similar across institutions (**Figure 2-1**). First, the student approaches the DRC and self-discloses that they have a disability and provides documentation[3]. After the documentation is approved, the student

[3] Directors described that documentation is required in most instances in order to receive accommodations. Examples of documentation often include official diagnoses from healthcare providers, psychoeducational evaluations, and Individualized Education Plans (IEPs) from high school that describe how the student's disability impacts them academically. A few directors described that for some apparent or visible

meets with a coordinator to discuss their needs and to identify potential challenges for their upcoming courses. Based on this conversation, the DRC coordinator and the student agree on *proactive accommodations* or accommodations that are identified to proactively alleviate potential challenges for the student in their upcoming courses. However, according to DRC directors, if a student is enrolled in an active learning course, they often experience challenges that are not accounted for in the initial meeting with the coordinator due to unique aspects of active learning. As such, the student must return to the DRC or initiate a conversation with the instructor after they experience a challenge with active learning to discuss the challenge that they are facing and to brainstorm *retroactive accommodations*, or accommodations to alleviate challenges that students have already experienced in their courses (**Figure 2-1**).

The challenge of providing accommodations retroactively is that it takes additional time and meetings to ensure that the student is provided with the accommodations necessary to be successful in a course. The additional steps that it takes for students to receive appropriate accommodations can lead to students feeling frustrated and they may be less likely to continue through with the process of securing an accommodation (Hong, 2015). Proactive measures can potentially reduce the amount of time it takes for the DRC, the instructor, and the student to accommodate the student's specific needs in active learning courses. Further, encountering challenges (such as many

disabilities (e.g. a student in a wheelchair), official documentation is not necessarily required but is up to discretion of the coordinator. Since obtaining documentation can often take time, some directors discussed implementing provisional accommodations until official documentation is received. Others discussed grants and other opportunities to financially assist students in obtaining appropriate documentation, particularly for students without health insurance.

of the challenges we describe in **Table 2-1)** may be embarrassing, frustrating, and upsetting for students and may result in lost course points. Proactive accommodations can benefit students by protecting them from experiencing these issues in the first place.

*The current state of proactive and retroactive accommodations for active learning in college science courses.* Despite all DRC directors being familiar with active learning-related challenges for students with disabilities, the majority of active learning-related accommodations are provided to students retroactively, meaning that students only identify that they need an accommodation once they have attended an active learning course. Only 16% of DRC directors were able to highlight an example when their DRC provided students with a proactive accommodation for an active learning course. In these cases, an individual within the DRC knew of an active learning science course, discussed active learning with the student and the possible challenges they might face before they started the course, and organized necessary proactive accommodations before the course began. Importantly, no DRC directors discussed systematic ways of proactively providing active learning accommodations for every student. That is, no DRC director that we interviewed had any systematic process in place for their institution that proactively identified active learning courses for students so that they could discuss accommodations prior to attending the first class. This could mean that, due to the lack of processes and procedures in place, students with disabilities enter science active learning courses unaware of the challenges they may face and may discover additional challenges late into the term as instructors introduce active learning techniques that may be new to the student. In these cases, students with disabilities may need to advocate for themselves in order to retroactively seek accommodations, which could have been prevented with more systematic procedures in place.

**Standardized vs. individualized accommodations.** DRCs are designed to offer students a variety of accommodations to meet their needs. Many students encounter a standard set of challenges and as such, standardized accommodations have been developed. These *standardized accommodations*, such as note-taking and extended test time, are commonly employed accommodations that are meant to improve the learning experiences of students with disabilities. However, at times the standardized accommodations are insufficient to meet a student's needs. In this case individualized accommodations are made when the student, DRC, and the instructor determine a unique accommodation for the student.

Legal mandates and best practices for disability services call for an individualized approach to accommodating students (Cory, 2011; Meeks & Jain, 2015). *Individualized accommodations* allow for each individual to be treated uniquely and are tailored to their specific needs. Indeed, many of the DRC directors that we talked to highlighted how they consider student needs and accommodations on a case-by-case basis and engage students in an interactive process of finding the appropriate accommodations. Directors also stated that it is not best practice to assume that two students with the same disability would necessitate the same accommodation for the same pedagogical practice in the same course, which is consistent with prior literature (Cory, 2011; Shaw & Dukes, 2001). However, the reality of the sheer number of students utilizing the DRC at large-enrollment institutions means that many DRCs do have a set of standardized accommodations that they draw from when deciding how to accommodate students in traditional courses, which often includes extended time for exams, reduced distraction testing environments, note-taking services, and interpreters. Importantly, many of the active learning-related challenges that DRC directors highlighted (**Table 2-1**) cannot be alleviated by using a standard accommodation. For example, while a note-taker may be useful to a student in a traditional lecture, a note-taker may struggle to accurately capture the thoughts generated in a small group discussion. Further, the note-taker would need to be in the same group as all of the students who need this accommodation, which would be logistically challenging in a large class. As such, it is likely that most active learning accommodations need to be individualized accommodations.

*The current state of standardized and individualized accommodations in active learning.* We were interested in whether any of the DRCs had developed standardized accommodations for active learning, or a suite of accommodations that can alleviate common challenges experienced by students with disabilities. We found that none of the 37 DRCs had standardized accommodations for active learning. DRCs exclusively developed individualized solutions for students on a case-by-case basis. In fact, all DRCs had provided students with an individualized accommodation for active learning at least one time with a total of 141 accommodations reported by directors. This is important because it shows that DRCs can accommodate students with disabilities in active learning courses. However, compared to standardized accommodations, individualized accommodations often take more time, resources, and effort from the DRC, instructor, and student. In **Table 2-2**, we highlight accommodations that were specific to active learning practices that DRC directors described implementing for students with disabilities. Interestingly, none of the institutions described using these accommodations regularly. However, looking across institutions, we identified several accommodations that were implemented across multiple DRCs. Below, we summarize some of the most used accommodations across institutions.

**Accommodations for small group work:** DRC directors mentioned the most examples of providing accommodations for small group work. Some of the example accommodations involve ensuring constructive group dynamics for students, such as allowing students to choose their own groups, instructors predetermining groups for students, and reducing group sizes or allowing students to just work in partner pairs. This could mean that some students are assigned to the same seats and groups for the entire semester where students can get comfortable getting to know and working with one another. For students who may have a difficult time interacting with group members face-to-face or who may be unable to attend class, directors facilitated students meeting with their group virtually, using an online platform such as Zoom where students could even interact with each other without their video turned on. Regarding constraints on the physical space of the classroom, DRC directors suggested, when possible, ensuring that the room had accessible tables, chairs, and furniture that facilitate small group work. However, given that many of these classroom spaces were not designed with group work and accessibility needs in mind, one director described requesting the instructor change the workplace setting to allow students to meet in the hallway or outside of the classroom. In cases where no other alternatives could be reached, some directors described allowing students to work alone or to complete an alternative assignment instead of working with their group.

**Accommodations for clicker questions:** With regard to the use of clicker questions in the classroom, directors described giving access to questions prior to class for students who may need more time to process the questions or having them complete the questions before or after class. This could be done by having the instructor post the slides and questions to the course learning management system or by requesting that the student visit their office before or after class to receive the necessary materials. Other accommodations included providing students with more time to respond to the question by having the instructor read the question aloud before starting the timer or allowing a student who may need additional time to motion to the instructor after they have had enough time to read the question. Additionally, DRC directors mentioned using classroom aides or volunteers to assist a student (e.g. a student with fine motor disabilities) in physically using their clicker. This individual could be someone who is hired by the university's DRC or it could be another student volunteer in the class. Further, DRC directors recommended ensuring that the clicker meets accessibility standards. For example, this could include making sure that the buttons are large enough for the student to press or that the buttons are labeled in braille for a student with vision loss. Some directors have had instructors implement clicker systems that use mobile apps or computer programs because these systems can be better for students if they are compatible with their existing adaptive technology (e.g. adaptive smartphones). Other directors mentioned that it is helpful if departments and universities use the same polling platform across courses for consistency for students who may receive clicker accommodations.

**Accommodations for cold call/random call:** DRC directors described several ways in which students can be accommodated when instructors use cold call and random call. These accommodations typically involve an agreement between the student and instructor about how, if at all, they wish to be called on. For example, instructors can notify students before they will be called on so that they have advanced notice to prepare. Alternatively, instructors can structure the class so that students discuss with their partner or group prior to speaking out in front of the whole class to ensure that they have had time to prepare an answer and so that they can speak on behalf of the group. In other instances, directors described students only being called on if their hand is raised or being able to opt out or pass if called on. As an alternative to speaking out in front of class at all, some directors described not having particular students be called on, and instead, having students submit their answers through a written form.

**Accommodations for required participation:** Nearly all directors who discussed issues with required participation also described the use of a flexible attendance and participation form that is agreed upon by both the student and instructor. While missing class is often detrimental in active learning courses, this agreement form ensures that there are clear expectations from both the student and instructor regarding participation in terms of the number of classes that can be missed or what constitutes adequate participation in the course. Some directors discussed situations where students attend class virtually by using Skype or Zoom to “attend” class from the hospital, home, or wherever they may be.

**Accommodations for online activities:** Several DRC directors mentioned that instructors worked with DRC staff and other university personnel, such as instructional designers, to ensure that videos are captioned and that tactile graphics or braille can be added to interpret online images or models. If an instructor does not know how to do this, many of the DRC directors mentioned having individuals in their office who can help. This often takes time, so DRC directors suggested reaching out to their offices as soon as possible when instructors are considering implementing new technologies in their courses. There are other existing assistive technologies that can help students navigate their online activities, such as screen readers. However, DRC directors recommended that instructors ensure that the online activities and software they choose have accessibility features and work with most assistive devices that students may already be using. DRCs may be able to point instructors to common software companies used in their discipline that are most accessible to students. In cases where students may have issues, directors said that either they or instructors notify software companies if and when their products are inaccessible to student users.

### (C) What steps can DRC directors and instructors take to enhance the experiences of students with disabilities in active learning science courses?

We drew from the current literature and our conversations with DRC directors to develop a list of four suggestions for DRC staff and science instructors who are looking to create more inclusive active learning environments for students with disabilities.

***1. Students may benefit from instructors being transparent about whether they teach in an active learning way and what specific active learning practices they tend to use.*** In order to better accommodate students with disabilities in active learning classrooms, DRCs need to know which science courses are taught in active learning ways and what practices instructors tend to use so that they can proactively identify solutions for students with disabilities who are enrolled in the courses *prior* to students engaging in class. Many DRC directors recommended that instructors provide both the DRC and the students information about how their science courses will be taught. Being explicit whether one teaches in an active learning way and what active learning practices are used in a course (e.g. small group work, clicker questions) in the syllabus and course directory could be helpful for DRCs and students working to identify proactive accommodations before the class begins. We encourage DRC directors to consider a systemic collection of course syllabi or to survey instructors yearly about which courses are taught using specific active learning practices. If this process is too time-intensive for the DRC staff, the onus could be placed on instructors by having them voluntarily send their syllabi or course description to the DRC to convey which active learning practices are used in the class. Having access to this information about active learning practices would allow DRCs to engage students in the accommodation process proactively.

***2. Students may benefit when instructors proactively design their course to be inclusive of students with disabilities.*** DRC directors suggested that instructors design their courses to be inclusive of students with disabilities and urged universities to find ways in which they can provide instructors with the necessary resources and support to make their classrooms more inclusive. Specifically, directors suggested that instructors could incorporate elements of Universal Design for Learning (UDL) (Rose & Meyer, 2002), which is a consistent recommendation among other studies of disability services staff (Burgstahler & Moore, 2009; Florida College System, 2009; Kalivoda & Totty, 2004). UDL is a framework, derived from architecture, that attempts to design accessible learning environments and curricula to accommodate all learners without specialized adaptation or accommodation (Burgstahler & Cory, 2008; Rose & Meyer, 2002). Common examples of implementing UDL in college science courses could include ensuring that all videos are closed-captioned, text sources are compatible with screen readers, and providing additional time for assessments and activities for all students (e.g. giving all students ten minutes to take a quiz that may only take five minutes). Several directors also mentioned that they have personnel on staff that are trained in UDL principles and are willing to help instructors implement it in their courses. The use of UDL principles in college science courses could reduce create a more inclusive environment for all students, including students with disabilities.

***3. When proactive accommodations are not possible, DRCs and instructors can support students with disabilities as they navigate the retroactive process in seeking accommodations***. Research has shown that individuals with disabilities can experience difficulties with self-advocacy and may specifically struggle with revealing to instructors their need for accommodations (Brinkerhoff et al., 2002; Hong, 2015; Lynch & Gussel, 1996). For many students, college is the first time that they are solely responsible for advocating for their disability-related needs (Eckes & Ochoa, 2005; Ochoa, 2007); as such, DRC directors described supporting students by coaching them about how to talk with their instructors about their disability and their need for accommodation.

Instructors can support students by making an announcement on the first day of class or on their syllabus that invites individuals with disabilities to approach them if they encounter a challenge in their classroom. Further, instructors can express their willingness to work with students with disabilities to provide appropriate accommodations and can provide students with information about their institution's DRC. Additionally, instructors can survey students about their identities (e.g. gender, college generation status, commute time to campus) to get a sense of who is in their class and the challenges they may encounter. As part of this survey, instructors could ask about disability status (see **Appendix A** for an example survey question). This would allow instructors to reach out to students who respond to this question to discuss proactive accommodations given the specific active learning exercises used in the course. The survey question uses the same categories of disabilities presented in this paper and could be used in future research to continue to uncover unique challenges and accommodations in active learning science courses from the perspective of students with specific disabilities.

***4. Standardize active learning accommodations.*** While there was no standardized set of accommodations that instructors could turn to when trying to accommodate a student in an active learning class, we noted that many of the accommodations that were developed for students were the same across institutions. However, there were also accommodations that were only used by one or two institutions. As such, sharing information about what individualized accommodations have been developed for students with disabilities in active learning classrooms may save time and effort for DRCs and students who are developing accommodations for challenges that may be new to them but that have been experienced by other students at different institutions. Overall, we favor increased crosstalk among DRCs about active learning through organizations such as the Association of Higher Education and Disability (AHEAD) and hypothesize that sharing information about developed accommodations could benefit both DRCs and students.

## Discussion

As college science classrooms are increasingly adopting active learning practices, it is imperative that the science education community consider what challenges active learning may pose for students with disabilities, how stakeholders are working together to alleviate such challenges, and what is working with regard to making active learning more inclusive for students with disabilities. We argue that a multi-pronged approach is needed: examining these questions through the lens of students with disabilities, of science instructors who teach in active learning ways, and DRC directors who implement accommodations across college campuses.

As a first step, we probed the perspectives of DRC directors. Through interviews with 37 DRC instructors, we have begun to identify an array of challenges that active learning may pose for students with disabilities. However, there are accommodations available that can be used to lessen such challenges, although there seem to be no standardized accommodations for students with disabilities in active learning classes and the majority of accommodations are put in place retroactively, after students have begun their coursework. Additionally, these interviews revealed key ways in which DRCs and instructors can make active learning science classes more inclusive: by being transparent and upfront about which active learning practices are incorporated into specific science classes, by proactively designing courses to be inclusive of students with disabilities, by helping students navigate retroactive accommodations when proactive accommodations are not possible, and by standardizing active learning accommodations.

While this essay was focused on active learning, we argue that we can use the guiding questions that we present in this essay to examine how inclusive other science learning environments are for students with disabilities, including undergraduate research experiences, lab courses, or traditional lecture courses. If we truly want to move toward creating a more diverse scientific community, then it is imperative that we, as education researchers and instructors, devote more time and effort to understanding the experiences of undergraduates with disabilities in science. If we do not make a substantial effort to be more inclusive of these individuals, and do not move swiftly to accommodate students as we transition our science classrooms from traditional lecture to active learning, then we may be losing out on retaining some of the best and brightest minds in science.

**Positionality**

The author physical disability and has previously used DRC accommodations as an undergraduate and graduate student (L.G.). Additionally, collaborators are proponents of active learning and have taught biology classes using active learning. We are all working to make our own active learning teaching more inclusive for students with disabilities and recognize that this is a very difficult, yet important, action to take.

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## Tables and Figures

**Table 2-1. DRC Director-Identified Challenges with Common Aspects of Active Learning for Students with Different Types of Disabilities.**
In parentheses, we report the percent of institutions implementing each challenge in a college science course at their institution.

| | | Type of disability | | | | | |
|---|---|---|---|---|---|---|---|
| Type of active learning practice | | **Learning disabilities (e.g. autism, dyslexia)** | **Mental health and psychological disabilities (e.g. anxiety, depression)** | **Physical disabilities (e.g. cerebral palsy, spina bifida)** | **Chronic health conditions (e.g. cancer, diabetes, Crohn's disease)** | **Visual impairments (e.g. blind)** | **Hearing loss (e.g. deaf)** |
| | **Small group work** | Students can have difficulties engaging with, working with, or sharing their thoughts with their group and/or instructor in a group setting (81%). | Students can have difficulties sharing ideas when working with others (57%). | Classroom layouts are not always conducive to group work for mobility devices, such as wheelchairs (11%).<br><br>Students can have difficulties writing quickly on group assignments (3%). | | | Students can have difficulties hearing group discussions (14%).<br><br>Off-site transcriptionists can have difficulties when there are multiple people talking to relay who is speaking (5%). |
| | **Clicker questions** | Students are not always provided enough time to process and answer clicker questions (32%). | | Students who have fine motor disabilities can have difficulties clicking buttons on clickers (32%). | | Students can struggle to see clicker questions that instructors typically post on a PowerPoint (51%).<br><br>Students have difficulties seeing their clicker and | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | clicking the correct buttons (46%). | |
| | **Cold/random call** | Students are not always provided enough time to process questions that they may be asked to answer in front of the whole class (32%).<br><br>Students have difficulties speaking in front of whole class (32%). | Sharing ideas with the whole class can exacerbate emotions such as anxiety, fear, and dread (51%). | | | | |
| | **Required participation** | | Student miss multiple class sessions because of their mental health disability, which may not be an excused absence (16%). | Students miss multiple class sessions because of their physical disability, which may not be an excused absence (68%). | Students miss multiple class sessions because of their chronic health condition, which may not be an excused absence (62%). | | |
| | **Online activities (e.g. online homework, videos)** | | | | | Online learning platforms and activities are not always accessible for students who receive information | Students often have difficulties hearing online videos and other online activities (5%). |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | in alternative formats (e.g. a student's adaptive technology may not be compatible with the online program or application) (43%). | Instructor videos are not always captioned and thus, students with hearing loss cannot receive the content of the video (11%). |

**Table 2-2. Director-Identified Accommodations for Students with Disabilities Based on the Type of Active Learning Practice.**
In parentheses, we report the percent of institutions implementing each accommodation in a college science course at their institution.

| Online activities | Required participation | Cold/ random call | Clicker questions | Small group work |
| --- | --- | --- | --- | --- |
| Instructor ensures all videos are captioned or replace with one that is already captioned (16%). | Student develops a flexible attendance and participation agreement form with the instructor (89%). | Instructor signals/notifies student that they will be called on soon to give advanced notice (24%). | Instructor provides student with access to clicker questions before class (22%). | Student is able to choose the group members to work with and does not change groups (8%). |
| Student works with an assistant to read and input answers online (8%). | Student can attend class virtually (e.g. Skype, Zoom) (5%). | Student is only called on when their hand is raised (8%). | Student sits close and motions to the instructor when they have had enough time to read/answer the question (3%). | Instructor pre-determines group for student (11%). |
| Instructor notifies 3rd party software companies that their products are inaccessible (16%). | | Instructor does not call on student to speak in front of class or can pass if called on (19%). | Instructor reads question aloud before beginning to time the clicker question (11%). | Instructor reduces the size of group student works in (14%). |
| Add tactile graphics, braille, or 3D models to online information (5%). | | Student submits answer through a written form (5%). | Instructor allows the student to complete clicker questions before or after class (5%). | Student can interact virtually with their group mates as an alternative to in-person (e.g. Zoom) (8%). |
| Student uses screen readers with online platforms (14%). | | | Instructor increases the amount of time a student has to answer clicker questions during class (14%). | A real-time captioner or scribe is placed within the student's group to record conversations (5%). |

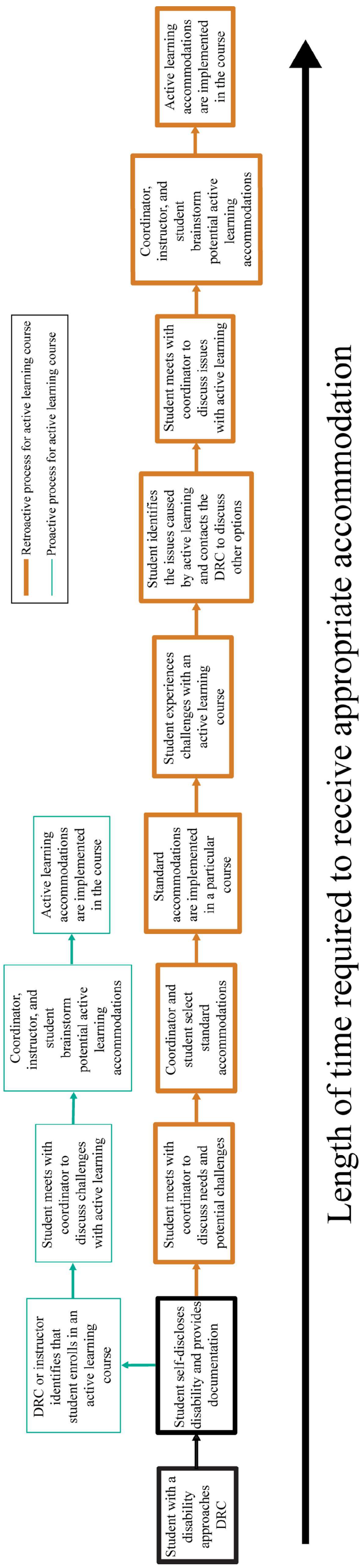
Retroactive process for active learning course
Proactive process for active learning course
Student with a disability approaches DRC
Student self-discloses disability and provides documentation
DRC or instructor identifies that student enrolls in an active learning course
Student meets with coordinator to discuss challenges with active learning
Coordinator, instructor, and student brainstorm potential active learning accommodations
Active learning accommodations are implemented in the course
Student meets with coordinator to discuss needs and potential challenges
Coordinator and student select standard accommodations
Standard accommodations are implemented in a particular course
Student experiences challenges with an active learning course
Student identifies the issues caused by active learning and contacts the DRC to discuss other options
Student meets with coordinator to discuss issues with active learning
Coordinator, instructor, and student brainstorm potential active learning accommodations
Active learning accommodations are implemented in the course
Length of time required to receive appropriate accommodation

**Figure 2-1. Processes for a Student with a Disability to Receive Accommodations in Active-Learning Science Courses.**

Orange lines represent the retroactive process of receiving accommodations for an active-learning course. Green lines represent how introducing proactive measures of accommodating students in active learning can reduce the number of steps required to reach a solution. The thickness of the lines represents the relative frequency of the pathway being used. This model of receiving traditional accommodations was adapted from Meeks and Jain (2015). We acknowledge that this process may be slightly different at each institution. For example, some institutions may require that instructors approve the accommodations agreed upon by the DRC and the student.

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CHAPTER 3

# 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 INSTIUTIONS

**Abstract**

The COVID-19 pandemic caused nearly all colleges and universities to transition in-person courses online. In this study, we explored how the rapid transition to online instruction during the COVID-19 pandemic affected students with disabilities. We interviewed 66 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 notetakers. 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), 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; over 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 enrolled in science, technology, engineering, and math (STEM) courses.

Students with disabilities are notably underrepresented in undergraduate STEM majors; individuals with disabilities comprise 26% of the US 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 to non-STEM courses and careers (Alston & Hampton, 2000; Duerstock & Shingledecker, 2014; A. Lee, 2011; Wells & Kommers, 2020). For example, STEM instructors have been shown to have lower expectations for students with disabilities compared to 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 (A. 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 to those without disabilities (Coleman-Jensen, 2020; Coleman-Jensen & Nord, 2013). 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 & 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 where instructors were already overwhelmed and without enough time. However, universities are legally mandated to provide appropriate accommodations to students with disabilities. There are two pieces of legislation that were passed in order 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 (Americans with Disabilities Act of 1990, 1990; ADA Amendments Act of 2008, 2008; Section 504 of the Rehabilitation Act, 1973; Meeks & Jain, 2015). To help facilitate compliance with these pieces of legislation, many colleges and universities have created disability resource centers (DRCs)[1], which are offices that provide academic and social services for students with disabilities, diagnosed medical conditions, and diagnosed mental health issues[2]. 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

[1] 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 the most general term used by many institutions.

[2] Although many individuals with mental health issues (e.g. depression, anxiety) may not consider their condition a disability, these individuals are supported by the DRC and they are considered students with disabilities by the university. 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.

(Americans with Disabilities Act of 1990, 1990; Section 504 of the Rehabilitation Act, 1973; 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 (Brinkerhoff et al., 2002; Dowrick et al., 2005; Eckes & Ochoa, 2005; Marshak et al., 2010). We knew little the extent to which DRCs and instructors were able to properly serve students with disabilities during the transition to online coursework 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.

Lastly, there is some evidence suggesting that students with disabilities face additional obstacles in any online 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 (Fawaz & Samaha, 2020; S. M. Lee & Oh, 2017; Wang et al., 2020). Additionally, students who are deaf[3] or hard of hearing can experience challenges with the online learning management systems, access to properly formatted course content and materials, and communication barriers with instructors and

[3] The "D" in Deaf often appears capitalized when referring to individuals who are pre-lingually 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.

other students (McKeown & 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 to 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 course 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 to answer 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) to what extent students with disabilities encounter challenges in education settings, (2) to what extent 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 & 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.

**<u>Interview recruitment</u>**

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 they forward our recruitment email for the interview study to registered students with disabilities at their institution. This email was meant to reach all students who were registered to receive accommodations at that particular institution. 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 **Appendix B**. We emailed a total of 150 directors. Of the 150 directors contacted, seven (5%) agreed to forward the interview recruitment onto 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.

**<u>Interviews</u>**

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. Prior to 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). We iteratively revised the interview protocol to clarify any question; we found that all questions functioned as intended during the second think-aloud interview. The interview questions probed the challenges that students may have experienced with the transition 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 **Appendix B** 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 semi-structured 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. While we included in a reminder email to students prior to interviewing that special accommodations could be arranged for the interview (e.g. interpreters), we did not have any students ask to use these services. We recognize that nature of these verbal interviews could have presented a challenge for students who are deaf or hard of hearing, so the students in our sample had at least some hearing capacity. 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 disability. A copy of the post-survey can be found in **Appendix B**.

**Interview analysis**

We used inductive coding methods to identify themes from the interviews (Birks & 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 & Peshkin, 1992). The two researchers finalized the codebook, which is included in the **Appendix B**. 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 $\kappa$ interrater score at an acceptable level ($\kappa = 0.94$) (Landis & 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 their 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 **Appendix B**. 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 related to classifying disabilities such as autism and attention-deficit/hyperactivity disorder (ADHD) as learning disabilities (Budd et al., 2016; Mayes et al., 2000); however, we have chosen to categorize these disabilities as learning disabilities because we hypothesize that students with autism and ADHD experience academic challenges that are more similar to those of students with other learning disabilities compared with students with mental health/ psychological disabilities in online learning environments. 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 generalizing to all individuals who share a disability type or specific disability.

**Analysis by disability type**

In our results, we chose to present themes that were highlighted 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 by doing so, our findings may be more representative of the experiences of students with disabilities that 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 13% (9 students) identified having three or more disabilities; this is consistent with other studies showing that disabilities are often co-occurring (Copley & Ziviani, 2004; Haydicky et al., 2012; Sareen et al., 2007). 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 (e.g. Karalunas et al., 2018; Merikangas et al., 2007). 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 pseudonym when a quote is presented and display tables showing what percent 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 dataset.

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 to the majority group. This study design mirrors others designed to describe the experiences of students in underrepresented groups in science (e.g. (Carlone & Johnson, 2007; Cooper et al., 2020; Cooper & Brownell, 2016; Leyva, 2016; Leyva & Alley, 2020).

**Positionality statement**

The author who conducted the interviews has a physical disability (L.E.G) and revealed his disability to students prior to 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 3-1**. Additional participant demographics, such as caregiving status and household income, can be found in **Appendix B**. 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 after the transition to online instruction because of the COVID-19 pandemic, they were unable to access many of these accommodations and resources. We identified four accommodations or resources that students accessed prior to 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 3-2**).

***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 the difficulties with taking tests from home, others offered concrete suggestions that would have made testing easier for them, such as having COVID-safe, socially distant testing environments on campus (e.g. converting classrooms into testing rooms) if they lived nearby campus or allowing exams to be open for longer of periods of time to be taken whenever possible, which could 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."*

***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 notetaker or that the DRC no longer facilitated providing notes from their peer notetaker. 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 notetaker [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, 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 & 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 shutdown 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 may 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, it also created a need for additional accommodations. Students with disabilities commonly described three challenges specific to the transition to online instruction that may have been lessened if they had had access to new accommodations (**Table 3-3**).

***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* (https://www.psionline.com/platforms/rpnow/) and *Gradescope* (https://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 had a negative impact on exam performance (Woldeab & 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 a student did not hear in an in-person course, they could ask the student sitting next to them, raise their hand and ask the instructor to repeat what they said, or approach the instructor after class. Students described that once their coursework 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 to ask questions in this environment to the instructor and 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 may have received 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 PowerPoint 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 benefitted from access to all lectures being recorded and posted online so that they could access the material when they needed. This could allow for students to go back to areas of the lecture that they may have missed, pause lectures, and re-watch 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 benefitted 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 highlighted 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 highlighted that most of these videos posted for a course did not include closed captions. For example, students like Bertha highlighted 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, 2013). However, this was often not possible after the course transitioned online because of how videos were recorded once instruction moved online.

*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. https://www.Amara.org, https://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. As such, we were interested in identifying what factors prevented students from receiving such accommodations. Students reported a number of barriers that stemmed from instructors and DRCs that prevented accommodations from being delivered efficiently and effectively (**Table 3-4**). As such, 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 & 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 highlighted 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 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 their accommodation once the course transitioned online or who were overwhelmed by transitioning coursework 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 & Murray, 2011; Love et al., 2014; Murray et al., 2009), it is likely inappropriate for them to make judgement 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 their 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 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 coursework. 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 their 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 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 highlighted 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 (Pfeifer et al., 2020; Terras et al., 2015). Indeed, the students in our study highlighted 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 highlighted that before the pandemic they used institutional resources, which closed after coursework 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 since they are more likely than their non-disabled peers to experience food insecurity and trouble finding employment during the pandemic (BLS, 2020; Coleman-Jensen, 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 state), 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 highlighted specific challenges with online learning that could have been lessened or even completely ameliorated if accommodations had been in place. In the past twenty years, the ways in which instructors teach students has changed dramatically (Elena & Lilia, 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 (AAAS, 2018; Stains et al., 2018). In active learning courses, instructors deploy an array of practices to engage students 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 prior to the COVID-19 pandemic, with some STEM bachelor's degrees being offered completely online (Allen & Seaman, 2013; Cooper et al., 2019; Mead et al., 2020; Varty, 2016). Studies have shown that students with disabilities feel as though they have less overall support and fewer accommodations for their disability in online courses compared to 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 coursework, 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 (US 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 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. Prior to 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. DREDF, 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 & 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 coursework, 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, disability is devalued, and there is a need to fix the individual with a disability (Goodley, 2014; Hehir, 2002). 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, but 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 that is often devoid of consideration of one’s identities has been proposed as promoting ableism in undergraduate STEM (Hall & 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 (Braun et al., 2018; Harshman et al., 2013; Mason & Hedin, 2011; McMahon et al., 2016). For example, students who are blind or 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 (Braun et al., 2018; Hauser et al., 2008). 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; Harris et al., 2019; Matz et al., 2017). The emphasis STEM courses place on high-stakes exams likely exacerbated issues with test-taking and proctoring that were highlighted 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 coursework more accessible for students with disabilities, both in the online courses during the pandemic and afterwards? 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 (Brinkerhoff et al., 2002; Lynch & Gussel, 1996; Pfeifer et al., 2020, 2021; Test et al., 2005). 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 affect 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 adopt an "ungrading" philosophy (Blum & Kohn, 2020) that focuses attention on learning, rather than a specific grade. Not only can these strategies be beneficial for students with disabilities, but recent evidence suggests that high-stakes testing can further exacerbate gender gaps between students (e.g. (Ballen et al., 2017; Eddy et al., 2014; Wright et al., 2016)). 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 (Burgstahler & Cory, 2008; Rose & Meyer, 2002; 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. Lastly, 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). As such, it is important to note that this work highlights the voices of students, but 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 hope that this work highlights areas that can be addressed in preparing for any online course or future time when in-person coursework would need to be rapidly transitioned to another platform.

Our recruitment methods asked DRC staff members 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 participation. 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 may have 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 only 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 a national level. The National Science Foundation report on Women, Minorities, and Persons with Disabilities in Science and Engineering only reports aggregated data on individuals with disabilities but does not provide a breakdown by disability type (National Science Foundation, 2019). Moreover, we our sample is comprised of primarily 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 (e.g. gender, race/ethnicity, etc.) and its intersections (e.g.(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 to explore students with disabilities through an intersectional lens, as we realize the challenges for recruiting a sample in order to conduct intersectional analysis. Finally, this study only examined student perceptions of their experiences during the pandemic and not their performance in courses. Based on the challenges with their accommodations, we would predict that their course performance was 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 that 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.

## Acknowledgements

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## Tables and Figures

**Table 3-1. 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) |
| Non-binary | 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 | |
| 1st year | 14% (9) |
| 2nd year | 18% (12) |
| 3rd year | 24% (16) |
| 4th year or more | 41% (27) |
| Decline to state | 3% (2) |
| Number of STEM courses enrolled in during spring 2020 | |
| One course | 18% (12) |
| Two courses | 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%.

**Table 3-2. The Percent of Students Who Reported Trouble Accessing a Specific Accommodation or Resource After the Transition to STEM Online Instruction due to the COVID-19 Pandemic.**

| Type of disability | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **All students**<br>**%**<br>**n = 66** | **Chronic health conditions (e.g. cancer, diabetes, Crohn's disease)**<br>**%**<br>**n = 22** | **Hearing loss (e.g. deaf)**<br>**%**<br>**n = 4** | **Learning disabilities (e.g. autism, dyslexia)**<br>**%**<br>**n = 36** | **Mental health and psychological disabilities (e.g. anxiety, depression**<br>**%**<br>**n = 43** | **Physical disabilities (e.g. cerebral palsy, spina bifida)**<br>**%**<br>**n = 10** | **Vision loss (e.g. blind)**<br>**%**<br>**n = 2** |
| 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 | 24% (16) | 36% (8) | 25% (1) | 11% (4) | 28% (12) | 30% (3) | 50% (1) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| resources | | | | | | | | |

Note: 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.

**Table 3-3. The Percent of Students who Reported a Unique Challenge with STEM Online Instruction That May Have Been Lessened with an Accommodation.**

| | Type of disability | | | | | | |
|---|---|---|---|---|---|---|---|
| | **All students**<br><br>**%**<br>**(n = 66)** | **Chronic health conditions (e.g. cancer, diabetes, Crohn's disease)**<br><br>**%**<br>**n = 22** | **Hearing loss (e.g. deaf)**<br><br>**%**<br>**n = 4** | **Learning disabilities (e.g. dyslexia)**<br><br>**%**<br>**n = 36** | **Mental health and psychological disabilities (e.g. anxiety, depression**<br><br>**%**<br>**n = 43** | **Physical disabilities (e.g. cerebral palsy, spina bifida)**<br><br>**%**<br>**n = 10** | **Vision loss (e.g. blind)**<br><br>**%**<br>**n = 2** |
| 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) |

Note: 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.

**Table 3-4. The Percent of Students who Reported a Barrier to Receiving Accommodations Effectively and Efficiently After the Transition to STEM Online Instruction during COVID-19.**

| | Type of disability | | | | | | |
|---|---|---|---|---|---|---|---|
| | **All students** % (n = 66) | **Chronic health conditions (e.g. cancer, diabetes, Crohn's disease)** % (n = 22) | **Hearing loss (e.g. deaf)** % (n = 4) | **Learning disabilities (e.g. autism, dyslexia)** % (n = 36) | **Mental health and psychological disabilities (e.g. anxiety, depression** % (n = 43) | **Physical disabilities (e.g. cerebral palsy, spina bifida)** % (n = 10) | **Vision loss (e.g. blind)** % (n = 2) |
| 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) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Students was required to self-advocate for accommodation modifications | 74% (49) | 64% (14) | 100% (4) | 78% (28) | 77% (33) | 80% (8) | 100% (2) |

Note: 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.

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CHAPTER 4

# NEW ONLINE ACCOMMODATIONS ARE NOT ENOUGH: THE MISMATCH BETWEEN STUDENT NEEDS AND SUPPORTS GIVEN FOR STUDENTS WITH DISABILITIES DURING THE COVID-19 PANDEMIC


## Abstract

The COVID-19 pandemic resulted in nearly all universities transitioning their in-person courses to online instruction. Recent work from our research team conducted in Spring 2020 established that the immediate transition to online learning presented novel challenges for students with disabilities: students were unable to access previously established accommodations and there was a lack of information from Disability Resource Centers (DRCs) about adapting accommodations to online environments. In this study, we aimed to determine the extent to which these issues still were present one year later. In Spring 2021, we conducted a survey of 114 students with disabilities who were registered with the DRC and taking online science courses at a public research-intensive institution. We used our previous interviews with students to develop closed- and open-ended questions to assess the extent to which students with disabilities were being properly accommodated in their courses, document any new accommodations they were using, and elicit any recommendations they had for improving their experiences in online science courses. We used logistic regression to analyze the closed-ended data and inductive coding to analyze the open-ended data. We found that more than half of students with disabilities reported not being properly accommodated, and this was more likely to be reported by students who experienced new challenges related to online

learning. When students were asked what accommodations they would have wanted, students often described accommodations that were being offered to some students but were not universally implemented. This study summarizes recommendations for making online science learning environments more inclusive for students with disabilities.

## Introduction

Colleges and universities are legally mandated to support students with disabilities[1]. Since 1973, students with disabilities have been legally protected from discrimination in institutions of higher education that receive federal funding, and the Americans with Disabilities Act (ADA) of 1990 further codified this into law (Americans with Disabilities Act of 1990, 1990; Section 504 of the Rehabilitation Act, 1973). Although the specifics of these accommodations are not outlined in the laws, the expectation is that students with disabilities will have equal access to higher education and that institutions will modify curricula or provide adequate accommodations so that students with disabilities can engage fully in their educational experiences (Eckes & Ochoa, 2005; Madaus, 2011; Meeks & Jain, 2015).

Importantly, undergraduate science education has changed dramatically since the passing of this legislation (Ali, 2019; Brubacher & Rudy, 2017; Englund et al., 2017). Chalkboards were replaced with transparencies, which have been replaced with PowerPoint slides. National recommendations for best practices in college education have promoted the transition from teacher-centered to student-centered learning, which changes the role of the student from passive listener to active contributor (American Association for the Advancement of Science, 2011; Freeman et al., 2014). Technological advances have introduced personal handheld clicker devices for hundreds of students to

[1] In this article, we use the term students with disabilities. The first author of the article has a physical disability and prefers to use this language. Some people advocate against using person-first language (e.g., person with a disability, person with autism) in favor of identity-first language (e.g., disabled person, autistic person) (D. S. Dunn & Andrews, 2015; Ferrigon & Tucker, 2019; Flink, 2021). However, person-first language has been officially endorsed by the American Psychological Association (APA, 2020).

simultaneously answer questions, microphone balls that can be thrown around the classroom, online platforms for discussions outside of class, and backchannel methods for students to ask questions without disrupting the class (Burns, 2017; Misseyanni et al., 2018; Smith et al., 2013). Thus, the conception of a college science classroom in 1973 and 1990, when these key pieces of legislature were introduced (Americans with Disabilities Act of 1990, 1990; Section 504 of the Rehabilitation Act, 1973), is now in many ways inaccurate.

In the evolution of college science instruction, COVID-19 and the emergency transition to remote learning served as a catalyst for dramatic changes in how instruction is delivered to students and a redefinition of what may constitute a college learning experience (Aguilera-Hermida, 2020). In March 2020, the need for social distancing sparked the enactment of remote learning almost universally (Baker et al., 2020; Hartocollis, 2020). Some courses were transitioned to a synchronous format with students interacting online with each other, while other courses provided students with asynchronous engagement with the materials at whatever time was most convenient for them, often through recorded lectures and online activities. The modality of online education has transformed what constitutes a class session from what happens in a physical classroom into a series of videos, online discussions, and online assignments. An important yet unanswered question is to what extent students with disabilities have been adequately supported after this transition. Has this evolution of learning also been accompanied by a concomitant evolution of accommodations and supports for students with disabilities?

To begin to answer this question, our research group conducted an exploratory interview study with 66 science, technology, engineering, and math (STEM) students with disabilities in June 2020, a few months after these students transitioned online due to COVID-19 (Gin et al., 2021). The interviews examined students' experiences immediately after the transition. We found that many students with disabilities were generally unable to access the accommodations that they used for their in-person science courses, such as reduced-distraction testing environments, additional test time, and note-taking, that were still necessary for their full engagement in online courses. We also identified that the transition to online science instruction created novel challenges for students with disabilities that required additional accommodations, such as closed-captioned video lectures and adapted test proctoring, which were often not provided to students. While these findings were concerning, it is possible that they primarily resulted from the need to transition online so quickly and the lack of notice provided to instructors and support services. Once colleges and universities had sufficient time to plan ahead to modify curricula and design online courses, were appropriate accommodations in place so that students were adequately supported? To address this question, we surveyed students with disabilities registered with the Disability Resource Center[2] (DRC) at a research-intensive institution about their experiences receiving accommodations in their

[2] We use the general term Disability Resource Center (DRC) to describe offices on college campuses that provide support for students with disabilities because it is commonly used on many college campuses. We recognize that some institutions may refer to these offices by other terms (e.g., accessibility resources, disability services, student access center).

online courses in March 2021, one year after these courses were transitioned to an online modality.

We wanted to explore the following research questions:

1. To what extent did science students with disabilities who reported new challenges in online learning report being properly accommodated?
    a. What challenges were not accommodated for?
2. To what extent did receiving new accommodations affect science students' perceptions of whether they were properly accommodated?
    a. What new accommodations did students receive?
3. What ideas do students have about how online science learning environments can be improved for students with disabilities?
    a. What specific accommodations do students recognize as important for improving their learning experience?

## Methods

The study was completed with an approved Institutional Review Board (IRB) protocol #13434 from Arizona State University.

### Recruitment

In Spring 2021, all instructors teaching undergraduate life science courses (n = 127) at a single research-intensive institution in the southwest United States that had transitioned their courses online due to COVID-19 were contacted and asked if they would be willing to send a survey to their students. Thirty-eight instructors (29.9%

response rate) agreed to send out the survey to their students and 2,175 students completed the survey.

**Survey**

The survey generally asked students about their experiences taking online science courses (defined as life sciences, chemistry, physics, or geosciences), during the Spring 2021 semester. Students who identified as having a disability[3] and reported that they registered with the Disability Resource Center[4] were asked a specific set of questions. These questions explored the extent to which students with disabilities experienced challenges with being accommodated, the extent to which students with disabilities were properly accommodated, the extent to which students were given new accommodations, and the types of accommodations students reported they would have liked to receive in their online science courses during the Spring 2021 semester. For a copy of the survey questions analyzed, see **Appendix C**.

**Data Analysis**

***To what extent did students who reported new challenges in online learning report being properly accommodated? What challenges were not being accommodated?***

Students with disabilities were given closed-ended questions asking, "Has the online format of Spring 2021 online science courses led to any new challenges for your disability?" and, "Given your disability, to what extent do you feel that you are currently

[3] We classify disability as one or more of the following: 1) learning disability (e.g., autism, dyslexia), 2) mental health/psychological disability (e.g., anxiety, depression), 3) physical disability (e.g., cerebral palsy, spina bifida), 4) chronic health condition (cancer, diabetes), 5) vision loss (e.g., blind), and 6) hearing loss (e.g., deaf).

[4] We acknowledge that there are students with disabilities who are not diagnosed and are unable to register their disability with the DRC. This may be due to stigma, financial challenges, or logistical challenges in obtaining the proper documentation.

being properly accommodated in your online college science courses?" We used descriptive statistics to determine the percentage of students who experienced new challenges and the percentage of students who reported being properly accommodated. To assess whether students who experienced new challenges were less likely to be properly accommodated compared to those who did not experience new challenges, we conducted a chi-square test. We confirmed that these data met the assumptions of chi-square and non-parametric tests (McHugh, 2013).

To assess what new challenges were not being accommodated, students who reported both experiencing new challenges online and not being properly accommodated were given a closed-ended question asking them to select any challenges they experienced in their online college science courses. This list was created from an in-depth interview study of 66 students with disabilities conducted during Spring 2020, which identified disability-related challenges students experienced when learning science online during the COVID-19 pandemic. Students also had the opportunity to write in any additional challenges they experienced that were not listed. Descriptive statistics were used to determine the most commonly reported challenges. Few students wrote in any additional challenges and any responses that were written could be categorized in an existing broader category.

***To what extent did receiving new accommodations affect students' perceptions of whether they were properly accommodated? What new accommodations did students receive?***

All students were asked “Have you actually received any new or adapted accommodations from the Disability Resource Center (DRC) for your Spring 2021 online science courses?” which they answered with a binary yes/no response. Descriptive statistics were used to identify the percent of students who received new or adapted accommodations and a chi square test was used to determine whether receiving new accommodations was more commonly reported by students who experienced new challenges compared to those who did not. We also confirmed that these data met the assumptions of chi-square and non-parametric tests (McHugh, 2013).

Additionally, we used logistic regression to determine whether students’ perceptions of being properly accommodated was predicted by experiencing new challenges in online learning and receiving new accommodations. We regressed whether students reported being properly accommodated on whether they experienced new challenges in online learning and whether they received new accommodations. We included an interaction term that included whether students experienced new challenges and received new accommodations because we predicted that for students with new challenges, being properly accommodated may be particularly dependent on whether or not they received new accommodations. Prior to conducting the regression, we calculated the variance inflation factor (VIF) using the car package in R for each predictor variable in the model (model: properly accommodated ~ new challenges + receiving new accommodations + new challenges * receiving new accommodations) to determine that our predictor variables were not too related to one another to be included in the same model (Craney & Surles, 2002; Fox & Weisberg, 2018). The VIF results confirmed that multicollinearity was not an issue. We also confirmed that there were no extreme outliers using the influence plot function in the car package in R (Fox et al., 2007).

Students who reported that they were given new accommodations were given a question asking them to describe any new accommodations they received in their online science courses. One researcher (S.E.B.) reviewed all student responses to this question and developed an initial rubric of themes that was given to two other researchers (L.E.G. & D.C.P.) (see **Appendix C**). Owing to the small number of written responses, the two researchers coded each response independently then met to discuss each code, discussed any discrepancies, and coded to consensus (Bradley et al., 2007; Richards & Hemphill, 2018).

***What ideas do students have about how online science learning environments can be improved for students with disabilities?***

Students were asked to "Please tell us about any ideas you have for accommodations in the online science learning environment that you are not receiving that could be helpful to you." Once again, one researcher (S.E.B.) reviewed the student responses to this question and developed an initial rubric of themes that was given to two other researchers (L.E.G. & D.C.P.) (see **Appendix C**). The two researchers used the rubric to code each response independently then met to discuss each code, discussed any discrepancies, and coded to consensus (Bradley et al., 2007; Richards & Hemphill, 2018). In addition to identifying accommodations that students would have found helpful, the researchers coded challenges that students described if alleviated could improve their experiences in online science learning environments. In the reporting of the results, pseudonyms were given to students to maintain their anonymity.

## Results

One hundred and fourteen (114) students with disabilities reported being registered with the Disability Resource Center. This represents 5.2% of the students[5] who completed the initial survey in their courses.

**Finding 1. More than half of students with disabilities reported not being properly accommodated during the Spring 2021 semester, which was more likely to be reported by students who experienced new challenges related to online learning.**

Of the 114 students registered with the DRC who answered the question asking whether they felt they were currently properly accommodated in their online science courses given their disability, 47.4% (n = 54) reported that they were properly accommodated and 51.8% (n = 59) reported that they were not (one student declined to state). Students were also asked whether they experienced new challenges related to their disability in the novel context of online learning; 60.5% (n = 69) reported experiencing new challenges, while 29.8% (n = 34) did not (11 students declined to state their answer to this question). Sixty-six percent of students who experienced new challenges online perceived that they were not properly accommodated, while 23.5% of students who did not experience new challenges online perceived that they were not properly

[5] This number likely underreports the total number of students with disabilities due to the stigma around disability as well as cost for receiving diagnoses for documentation with Disability Resource Centers (Whittle et al., 2017).

accommodated; students who experienced new challenges were significantly more likely to report not being properly accommodated ($\chi^2 = 14.9$, $p<0.001$, **Figure 4-1**).

Students who experienced new challenges and did not feel properly accommodated (n = 45) were asked to select challenges that they experienced from a list developed from our previous interview study of students with disabilities engaged in online courses. One year after transitioning to online instruction, the most common challenges that students identified in the online learning environment were video proctoring software challenges (62.2%), accessing distraction-free testing (55.6%), the requirement for individuals to spend additional time on their computers (53.3%), instructors not recognizing their accommodation (48.9%), and instructors forgetting a student's accommodation (42.4%). See **Table 4-2** for a full list of challenges and the percentage of students who reported each.

**<u>Finding 2. Receiving new accommodations did not affect students' perceptions of whether they were properly accommodated in the online learning environment</u>**

Nearly 38% of students (n = 43) reported receiving new accommodations in response to the transition to online courses; students who reported new challenges were more likely to report receiving such accommodations than students who did not ($\chi^2 = 10.1$, $p = 0.001$). We hypothesized that receiving accommodations would predict whether a student felt properly accommodated, especially among students who experienced novel challenges while learning science online. However, when we regressed whether students perceived they were properly accommodated on whether they experienced novel challenges and whether they received new accommodations, accounting for an interaction effect, we found that whether students received new accommodations did not predict whether a student felt they were properly accommodated (**Table 4-3**). The only significant predictor was whether a student experienced new challenges learning science online. This indicates that these novel accommodations were not necessarily properly addressing the new challenges emerging for students with disabilities in online science courses.

Students who reported receiving new accommodations (n = 43) were asked an open-ended question about what new accommodations they were receiving. The most common accommodations that students were receiving one year after the transition to online instruction were additional extended testing time (46.5%), flexible assignment deadlines (27.9%), recorded lectures and class meetings (9.3%), flexible class attendance (7.0%), and online note-taking services (7.0%). See **Table 4-4** for a full list of new accommodations that students reported.

**Finding 3. When discussing how to improve online science education for students with disabilities, some students identified that additional accommodations were needed, while others honed in on challenges related to delivering accommodations that need to be mitigated.**

We asked all students who reported not being properly accommodated about their ideas for accommodations in online science learning environments that they are not receiving and would find helpful. Interestingly, students mentioned an array of accommodations that other students were already receiving but that had not been offered to all students (even students with the same disability type). For example, students mentioned that they wanted attendance flexibility, having flexible due dates for assignments, or extended deadlines – all accommodations that other students reported receiving. A full list of accommodations that students reported could have been helpful is reported in **Table 4-5**.

Interestingly, many students chose not to write about a specific accommodation in response to the question asking them what would have been helpful given their experience learning science online and instead some expressed challenges that they encounter, which if alleviated, would have improved their experience. For example, some students indicated that it was up to the instructor's discretion about whether to provide an accommodation or accept a particular student's request for an accommodation.

> "I do respect professors' wishes and by no means mean this in a disrespectful way, but the DRC only saying students can receive certain accommodations if the instructor says yes, and having the DRC advisors questioning your accommodation requests is really emotionally draining in itself." - Morgan (new challenges, no new accommodations)

> "I want professors to recognize that I am supposed to get extensions on assignments. It's part of my accommodations and still some [professors] don't provide it." - Gaby (new challenges, new accommodations)

Instructors deciding whether particular accommodations are appropriate for students is concerning given that instructors do not receive any training in student disabilities or what could be an appropriate accommodation (Gokool-Baurhoo & Asghar, 2019; Love et al., 2014). Even instructors who had significant teaching experience were likely inexperienced teaching online.

It appeared that some instructors had unrealistic expectations with respect to how far in advance a student with a disability could ask for an extension, which highlights a mismatch in expectations and knowledge about certain disabilities.

> "I have been asked to provide warnings in advance when my disability will cause me to need an extension, but my disability doesn't always give me an itinerary and I am not able to predict when I will need help. As a result, I have had repeatedly missed assignments and I have been told [by instructors] I should have planned ahead. Professors need to understand that many of us cannot plan when our disability will affect us." - Kyle (new challenges, new accommodations)

Further, there seemed to be disconnects in what instructors were told to do by the DRC and what they knew how to do.

> "There needs to be updates in professor knowledge about extending test times when courses are online. I've had many professors struggle with this or do it incorrectly." - Lauren (no new challenges, no new accommodations)

In sum, while additional accommodations may improve the extent to which students with disabilities feel properly accommodated, the substantial challenges some encountered when trying to access existing accommodations sheds light on the nuance of accommodation delivery.

## Discussion

This study explored how students with disabilities registered with the DRC were accommodated in their online instruction one year after the transition to online learning due to COVID-19. Although institutions and instructors had almost a year to identify challenges and accommodations for students with disabilities online, we found that many students with disabilities were still not being properly accommodated in their online courses. Our finding that students with new challenges received new accommodations, but that they did not perceive that they were properly accommodated, reveals that these new accommodations may not be sufficient.

It was perplexing that students with the same type of disability were not offered similar accommodations. Although the same disabilities can present differently and result in unique challenges (Brown, 2002; Shakespeare, 2006), this highlights the lack of standardization of accommodations, particularly in response to novel teaching environments (Gin et al., 2020). One of the major issues that we identified was the lack of accountability on the part of instructors. Institutions are legally mandated to provide accommodations to students with disabilities and the DRCs contact instructors about what the proper accommodations would be for each student (Gin et al., 2020; Madaus, 2011). However, there is often very little follow-up to see if an instructor has implemented the accommodation. Further, if an instructor is unwilling to provide an accommodation, then it puts the student in a tenuous position where they are forced to self-advocate in ways that may jeopardize their relationship with the instructor and simultaneously any subjective grading in the course (Marshak et al., 2010; Pfeifer et al., 2020, 2021).

We consider this to be a systemic problem due to the interconnectedness of how students with disabilities are supported (Gin et al., 2020; Meeks & Jain, 2015). Students with disabilities have to bring their diagnosis to the DRC and that DRC contacts the instructor about the appropriate accommodations (Ben-Simon et al., 2008; Lovett et al., 2015). There is not typically an opportunity for an instructor to share with the DRC what changes they have made to their courses, or what accommodations might be most appropriate given their instructional strategies (Gin et al., 2020). If students experience something challenging in their course they can address it with the DRC, but this accommodation then is introduced retroactively, often weeks or even months into the term, especially since more students, in general, are registering with the DRC but there have not been associated increases in staff (Gin et al., 2020). The confidentiality of student disability means that instructors know that a student has a disability, but do not know what that disability is, making it difficult for instructors and students to work together to solve a problem without the involvement of the DRC (C. Dunn et al., 2012; Love et al., 2014). If students self-advocate with the instructor, they may risk disclosing their identity and suffer unconscious bias or discrimination for their disability (Fine & Asch, 1988; Lyons et al., 2017; Santuzzi et al., 2014). Thus, the compounded challenges of DRCs not being experts in novel pedagogies, instructors not being experts in disabilities and disability supports, and students needing confidentiality for their disability means that often students with disabilities are not adequately supported in innovative learning spaces (Dowrick et al., 2005; Kyvik, 2015; Marshak et al., 2010). Further, DRCs are understaffed, instructors developing online courses for the first time are often overworked and under a time crunch, and students are dealing with additional financial and mental health challenges of the pandemic, highlighting the systemic nature of this problem (Adedoyin & Soykan, 2020; Huckins et al., 2020).

So, what are the solutions? First, institutions must better support their DRCs through increased staff and training about pedagogical innovations. This requires a financial investment, but this is critical for institutions to meet their legal obligations for students with disabilities. Second, institutions need to require instructors to better understand the needs and supports for students with disabilities. Similar to trainings required for fire safety or data management, instructors could be required to complete an online training to help equip them to better understand students with disabilities and their responsibilities as instructors (e.g., Access Zone). Third, institutions need to monitor instructor compliance with disability accommodations and sanction instructors who did not comply. Fourth, institutions can help create communication pathways between instructors and DRCs so DRCs have a better idea of what types of teaching strategies are being used in an instructor's class (Gin et al., 2020). This could be particularly helpful for large-enrollment courses to avoid the need for multiple students with disabilities individually self-advocating. Fifth, instead of each institution acting in isolation, shared networks of institutions and individuals interested in better supporting students with disabilities could help provide resources for students, instructors, and DRCs. Sixth, it is critical that funding and time is spent in the research and development of high-quality and evidence-based online accommodations that can become standardized, similar to the common suite of accommodations for in-person courses (which likely needs to be updated as per the first recommendation). These recommendations have been summarized and provided as a table that can easily be distributed to DRCs, instructors, and other support staff involved in accommodating students with disabilities in novel learning environments (**Table 4-6**).

## Limitations

This work was conducted at a single research-intensive institution and this work would benefit from being replicated at other institution types (Schinske et al., 2017). Notably, all participants who participated in this study were registered with the DRC. However, being registered requires a diagnosis and we know that healthcare is disproportionately unavailable to low-income individuals and Communities of Color (Artiga et al., 2020). As such, the number of students with disabilities who reported not being properly accommodated when learning science online is likely an underestimate of the total number of students with disabilities who feel this way.

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## Tables and Figures

**Table 4-1. Demographics of Students who Completed Survey, Including Disability Types.**

| (n = 114) | n (%) |
|---|---|
| **Disability type[a]** | |
| Mental health | 98 (86.0) |
| Learning | 39 (34.2) |
| Chronic health condition | 29 (25.4) |
| Vision | 3 (2.6) |
| Physical | 7 (6.1) |
| Hearing | 5 (4.4) |
| Other | 28 (24.6) |
| **Gender** | |
| Man | 12 (10.5) |
| Woman | 88 (77.2) |
| Non-binary | 12 (10.5) |
| Decline to state | 2 (1.8) |
| **Race/ethnicity** | |
| Asian/Pacific Islander | 11 (9.6) |
| Black/African American | 3 (2.6) |
| Latinx | 15 (13.2) |
| Native American | 1 (0.9) |
| White | 74 (64.9) |
| Other | 6 (5.3) |
| Decline to state | 4 (3.5) |
| **College generation status** | |
| First generation | 44 (38.6) |
| Continuing generation | 67 (58.8) |

| | |
|---|---|
| Decline to state | 3 (2.6) |
| **Academic year in school** | |
| First year | 23 (20.2) |
| Second year | 31 (27.2) |
| Third year | 26 (22.8) |
| Fourth year | 22 (19.3) |
| Fifth year or more | 11 (9.6) |
| Decline to state | 1 (0.9) |
| [a] Students could select multiple disabilities on the survey. Therefore, percentages add up to greater than 100%. | |

**Table 4-2. The Percent of Students who Indicated They Experienced Each Challenge During Their Online College Science Courses.**

| (n = 45) | % (n) |
|---|---|
| Challenges | |
| Video proctoring software | 62.2 (28) |
| Accessing distraction-free testing | 55.6 (25) |
| Extra time on computer | 53.3 (24) |
| Instructor did not recognize accommodation | 48.9 (22) |
| Instructor forgot accommodation | 42.2 (19) |
| Accessing additional exam time | 22.2 (10) |
| Accessing video lectures | 20.0 (9) |
| Accommodation cannot be delivered online | 11.1 (5) |
| Accessing note-taking services | 6.7 (3) |
| Other | 4.4 (2) |

**Table 4-3. Regression Output for Challenges and Accommodations.**

| Variable | *B* | *SE B* | *z* | *p* |
|---|---|---|---|---|
| (Intercept) | 1.34 | 0.46 | 2.93 | 0.003 |
| New challenges | -2.26 | 0.59 | -3.82 | < 0.001 |
| New accommodations | -0.94 | 1.02 | -0.92 | 0.36 |
| New challenges * New accommodations | 1.42 | 1.14 | 1.24 | 0.21 |

**Table 4-4. New Accommodations Received by Students.**

| (n = 43) | % (n) |
|---|---|
| New accommodations | |
| Additional extended testing time | 46.5 (20) |
| Flexible assignment deadlines | 27.9 (12) |
| Recorded lectures and class meetings | 9.3 (4) |
| Flexible class attendance | 7.0 (3) |
| Online note-taking services | 7.0 (3) |
| No exam lockdown browsers/cameras | 4.7 (2) |
| Closed-captioning of videos and lectures | 4.7 (2) |
| Option for cameras off during class | 4.7 (2) |
| Reduced distraction home environment (e.g., earplugs) | 4.7 (2) |
| Instructors share slides prior to class | 2.3 (1) |
| Work in smaller (breakout) groups | 2.3 (1) |
| Use of clear masks by instructor | 2.3 (1) |

**Table 4-5. Accommodations that Students with Disabilities Reported Would Have Been Helpful to Them When Learning Science Online.**

| (n = 44)[a] | % (n) |
|---|---|
| Accommodations that could have been helpful | |
| Flexible assignment deadlines | 25.0 (11) |
| Additional extended testing time | 13.6 (6) |
| More frequent communication from instructors about expectations and due dates | 11.4 (5) |
| No exam lockdown browsers/cameras | 9.1 (4) |
| Closed-captioning of videos and lectures | 6.8 (3) |
| Eliminating all timed assignments | 6.8 (3) |
| Open-book exams | 4.5 (2) |
| Flexible class attendance | 4.5 (2) |
| Online note-taking services | 2.3 (1) |
| Recorded lectures and class meetings | 2.3 (1) |
| Work in smaller breakout groups | 2.3 (1) |
| Option for cameras off during class | 2.3 (1) |
| Reduced distraction home environment (e.g., earplugs) | 2.3 (1) |
| Instructors share slides prior to class | 2.3 (1) |
| Socially distant testing centers on campus | 2.3 (1) |
| Requests for printed materials | 2.3 (1) |

[a] The number of students who reported each accommodation that could have been helpful was divided by the total number of students who reported an accommodation in response to this question.

**Table 4-6. Proposed Recommendations for Fully Accommodating Students with Disabilities in Online Science Learning Environments.**

| |
|---|
| Recommendation 1: Increase DRC staff and trainings to support pedagogical innovations |
| Recommendation 2: Require training for instructors to better understand and support students with disabilities |
| Recommendation 3: Monitor instructor compliance with disability accommodations and sanction non-compliance |
| Recommendation 4: Create communication pathways between instructors and DRCs to discuss teaching strategies |
| Recommendation 5: Encourage institutions to share resources for better supporting students with disabilities |
| Recommendation 6: Research and development of high-quality and evidence-based online accommodations |

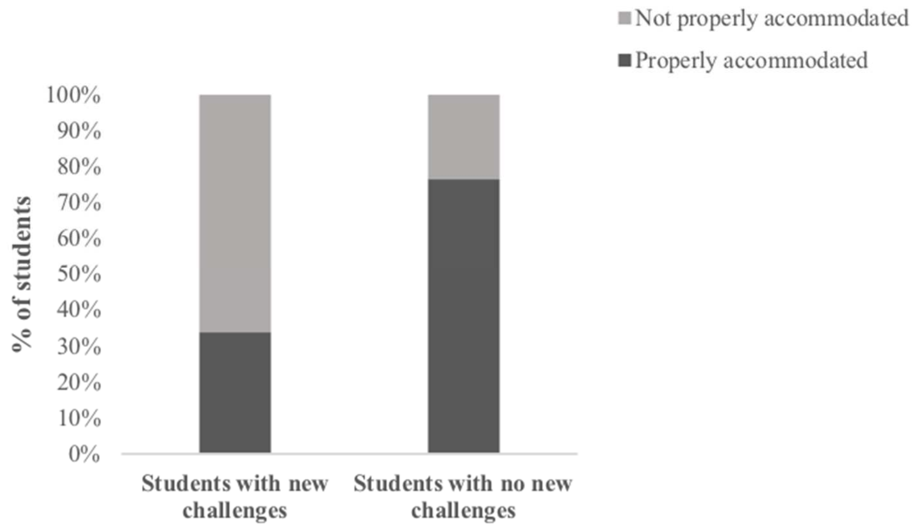


**Figure 4-1. Percentage of Students Who Reported Being Properly Accommodated in Their Online College Science Courses Based on Whether They Have Experienced a New Disability-Related Challenge in Online Learning.**
Students who experienced new challenges (n = 69) and students who did not experience new challenges (n = 34) are separated along the x-axis. Students who experienced new challenges were significantly more likely to report not being properly accommodated ($\chi^2 = 14.9$, $p < 0.001$).

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# CHAPTER 5

## STUDENTS WITH DISABILITIES IN UNDERGRADUATE RESEARCH: CHALLENGES AND OPPORTUNITIES


### Abstract

Individuals with disabilities are underrepresented in postsecondary science education and in science careers, yet few studies have explored why this may be. A primary predictor of student persistence in science is participating in undergraduate research. However, it is unclear to what extent students with disabilities are participating in research and what the experiences of these students are like. To address this gap in the literature, in Study I, we conducted a national survey of over 1200 undergraduate researchers to determine the percent of students with disabilities participating in undergraduate research in the life sciences. We found that 12% of undergraduate researchers that we surveyed self-identified as having a disability compared to 18% of life science majors, which indicates that students with disabilities are likely underrepresented in undergraduate research. In Study II, we conducted semi-structured interviews with 20 undergraduate researchers with disabilities. We identified unique challenges experienced by students with disabilities in undergraduate research, as well as some possible solutions to these challenges. Further, we found that students with disabilities perceived that they provide unique contributions to the research community. This work provides a foundation for creating undergraduate research experiences that are more accessible and inclusive for students with disabilities.

## Introduction

Individuals with disabilities[1] are underrepresented in postsecondary science education; while they are estimated to make up about 26% of the US population, they comprise 18% of individuals pursuing an undergraduate degree in the life sciences and only about 10% of those graduate college with a life sciences degree (Centers for Disease Control and Prevention, 2018; National Science Foundation, 2016). It is becoming increasingly clear that students with disabilities experience unique challenges in undergraduate science, including facing discrimination and enduring inaccessible classroom learning environments, which are thought to contribute to their attrition from science degree programs (Begay-Campbell et al., 2010; Fayer et al., 2017; Zablotsky et al., 2017). However, there is a growing recognition that there are specific high-impact practices, which are often not part of the standard college science curriculum, that can greatly influence a student's persistence in science. It is not well known to what extent students with disabilities participate and thrive in these high-impact practices, such as undergraduate research, that are known to increase student persistence in undergraduate science programs (Hathaway et al., 2002; Hernandez et al., 2018; M. T. Jones et al., 2010; Nagda et al., 1998) and their chances of going to graduate school (Bauer &

[1] In this article, we primarily use person-first language when describing students with disabilities generally, which has been promoted as a way to indicate that the individual is a person first, who happens to have a disability (APA, 2020; NCDJ, 2018). However, there are specific communities that have advocated for identity-first language (e.g., autistic community, deaf community, blind community) (Kenny et al., 2016; Lum, 2010; Vaughan, 2009). Importantly, there is not widespread agreement on what type of language is most preferred among those in the disability community ((Ferrigon & Tucker, 2019).

Bennett, 2003; Carter et al., 2009; Hernandez et al., 2018; Russell et al., 2007; Seymour et al., 2004). In this article, we examine the representation of students with disabilities in undergraduate research and explore the unique experiences of students with disabilities engaging in research to further understand how colleges and universities might leverage this high-impact practice to improve the persistence of students with disabilities in science.

Increasing the representation of individuals with disabilities in science has become a priority for national funding agencies (NCSES, 2021). Having individuals from diverse backgrounds engaging in science is integral to national success because it can lead to a stronger, more talented U.S. workforce that can meet the demands of a 21st century economy (NSF, 2012) and increase the objectivity of science by including individuals with unique perspectives that can influence scientific questioning and interpretation (Intemann, 2009). Societal norms, attitudes, and ableist structures contribute to the historic underrepresentation of individuals with disabilities in science (Oliver, 2013; Sins Invalid, 2019). Undergraduate courses are often taught in ways that are inaccessible to students with disabilities and these ableist course design structures can discriminate against individuals with disabilities, often in ways that may not be apparent to an instructor (Goodley, 2014; Hehir, 2002). For example, teaching practices in science courses (e.g., asking students to work together or asking students to speak out in front of the whole class), content delivery (e.g., in-person vs. remote vs. hybrid), and course and university policies (e.g., required attendance in a course, required wet lab course for a science major) can create unique challenges for students with disabilities (Gin et al., 2020; Gin, Guerrero, et al., 2021; Hutcheon & Wolbring, 2012). As such, students with disabilities often require accommodations, defined as modifications, auxiliary aids, and services, to facilitate their participation in university courses (Meeks & Jain, 2015). Even though adequate accommodations for college coursework are legally mandated, students with disabilities often need to self-advocate, or actively assert their needs and rights, in order to secure required supports (Izzo & Lamb, 2002; Martin & Marshall, 1995; Test et al., 2005). The process of self-advocating has been shown to be a critical, yet challenging, part of navigating undergraduate education in general (Hadley, 2007), as well as in science-specific learning contexts (Gin et al., 2021; Pfeifer et al., 2020, 2021). In fact, science disciplines have been reported to be particularly exclusionary of students with disabilities. For example, science majors with disabilities often receive fewer accommodations in their courses compared to non-science majors with disabilities (Lee, 2011). Additionally, one study found that college science instructors doubt the abilities of students with disabilities, and also lack the knowledge and experience required to provide proper accommodations for science coursework (Dunn et al., 2012). As such, it may be particularly difficult for students to self-advocate in the context of college science courses (Pfeifer et al., 2020, 2021).

The primary approach to improving attrition among college students with disabilities in science has been to reduce barriers to success in undergraduate education broadly, often by providing accommodations in their courses or offering replacement courses if they cannot fully participate in a particular course (e.g., a lab course) (Dunn et al., 2012). However, many of these accommodations are designed so that students can achieve equivalent knowledge or grades in a course; this approach takes a narrow view of what higher education entails and assumes that coursework and grade point average are the most important factors influencing a student's decision to engage in science. In contrast, many educators view higher education as a holistic experience and believe the engagement of students in high-impact practices, which may or may not take place in formal courses, is critical to one's persistence and success in college (Kuh, 2008). High-impact practices are defined as teaching and learning practices that have been widely tested and shown to be beneficial for college students by increasing student engagement and retention (Graham et al., 2013; Kuh, 2008; Russell et al., 2007). The Association for American Colleges and Universities (AACU) defines eleven high-impact practices for undergraduates, which include: first-year seminars and experiences, common intellectual experiences, learning communities, writing-intensive courses, collaborative assignments and projects, diversity/global learning, ePortfolios, service learning/community-based learning, internships, capstone courses and projects, and undergraduate research (Kuh, 2008). Thus, we argue that the approach to retaining undergraduates with disabilities in science should be multifaceted and extend beyond just providing the minimal accommodations appropriate for coursework. Another strategy to help increase the persistence of students with disabilities could be to increase the participation of students with disabilities in high-impact practices.

Undergraduate research is a high-impact practice that national science agencies and science educators recommend all students engage in, owing to the wide array of skills and benefits that it can provide (Kuh, 2008; National Academies of Sciences &

Medicine, 2017; National Research Council, 2012). Specifically, engaging in undergraduate research experiences (UREs) can lead to increased student-perceived understanding of how to conduct scientific research (Russell et al., 2007), as well as student confidence in their ability to think critically (Bauer & Bennett, 2003; Brownell et al., 2015). Further, participation in undergraduate research has been shown to enhance student learning (Brownell et al., 2015; Rauckhorst et al., 2001) and bolster students' confidence in their ability to conduct research (Bauer & Bennett, 2003; Seymour et al., 2004). Undergraduate research has been shown to prime students' career goals and aspirations to become scientists (Eagan Jr et al., 2013) and is a robust predictor of student persistence and completion of undergraduate science degrees (Graham et al., 2013; Hernandez et al., 2018). For example, a 10-year longitudinal study showed that students who completed at least 10 hours a week of faculty-mentored research across two academic terms were more likely to graduate with a science-related bachelor's degree and be accepted into a science-related graduate programs compared to students who did not engage in research (Hernandez et al., 2018). Further, undergraduate research has been shown to be a positive predictor of who excels once admitted into science-related graduate programs (Bauer & Bennett, 2003; Carter et al., 2009; Hernandez et al., 2018; M. T. Jones et al., 2010). In sum, engaging in undergraduate research has tremendous potential to positively impact a student's persistence and experience in the sciences.

Participating in undergraduate research has been thought to be an especially important activity for individuals who are underrepresented in science (NAS, 2017). Specifically, a study of students who participated in a minority training program that included undergraduate research found that participants had higher scientific-related career aspirations compared to students who did not participate in research (Schultz et al., 2011). Another study of graduate students who identify as persons excluded based on their ethnicity or race (PEERs), found that students highlighted their experience in undergraduate research as a key factor that influenced their decisions to pursue a PhD and stay in science (Villarejo et al., 2008). Additionally, underrepresented students, particularly from Latinx backgrounds, have been shown to experience unique gains in knowledge and skills from participating in undergraduate research (Daniels et al., 2016). Encouragingly, studies have shown that PEER undergraduates engage in research at the same rate or a higher rate than their white colleagues (Lopatto, 2004, 2007; Russell et al., 2007). Despite the evidence suggesting that research is indeed beneficial to individuals who are underrepresented in science because of their ethnicity or race, there is much less known about the experiences of students with disabilities in research and how such students may uniquely benefit from these experiences.

The majority of extant literature on undergraduate research and individuals with disabilities includes deaf and hard of hearing students probing their experiences in scientific research environments where they are surrounded by hearing peers and mentors (Braun et al., 2018; Gehret et al., 2017; Pagano et al., 2015). There are concerns that deaf and hard of hearing students are not able to easily communicate and connect with others in the lab, so they end up working in more isolated situations, which can result in negative research experiences (Gehret et al., 2017, 2021; Majocha et al., 2018; Thiry & Laursen, 2011). Group discussions with multiple people talking over one another can be hard for these students to follow along, and students acknowledged that without an interpreter standing by at all times, they missed learning opportunities in the research lab. Notably, support services for interpreters are costly and priority often goes to classrooms, not research labs; even when interpreters are present in the research lab, they often are unsure of their role and may not have signs for some of technical jargon, making them less effective than in other situations (Ott et al., 2020). Additionally, research mentors can be unaware of how they may marginalize deaf students and make them feel as though they do not belong by both their explicit statements and implicit behaviors, often inadvertently promoting ableism (Braun et al., 2018; Lynn et al., 2020). Other studies have explored the experiences of students with depression, some of whom consider their depression as a disability. These studies found that specific aspects of research, such as failing and lack of guidance, can exacerbate students' depressive symptoms (Cooper, Gin, Barnes, et al., 2020; Gin, Wiesenthal, et al., 2021). Further, many students with depression are uncomfortable sharing this identity with their peers and mentors, which would limit their ability to get support and accommodations (Cooper, Gin, & Brownell, 2020). However, we know of no other literature on the experiences of students with other disabilities in research.

Previous research has established that students with disabilities can experience challenges with navigating different biology learning environments because individuals traditionally involved in students' education (e.g., instructors) are unfamiliar with available resources (Baker et al., 2012; Cole & Cawthon, 2015; Roth et al., 2018). For example, students with disabilities are traditionally supported by a university's Disability

Resource Center (DRC)[2]. DRCs are offices that provide services to students with disabilities and other diagnosed medical conditions to ensure compliance with both educational and civil rights law which mandates that students with disabilities be reasonably accommodated (Americans with Disabilities Act of 1990, 1990; Section 504 of the Rehabilitation Act, 1973). While support services for students with disabilities are available on nearly every college and university campus (Madaus, 1996, 2011), some students may be unaware of the presence of the DRC or be unsure of the range or types of accommodations that may be available to them through the DRC (Dowrick et al., 2005; Gin et al., 2021; Marshak et al., 2010). Most DRCs are well equipped to support students with disabilities in traditional learning environments, such as a traditional lecture courses; however, DRCs are not as prepared to serve students in innovative learning environments, such as active learning classrooms (Gin et al., 2020; Meeks & Jain, 2015) and online courses (Gin et al., 2021). It is unclear to what extent DRCs help students navigate challenges in other unique learning environments, such as undergraduate research, even when students engage in research for academic credit, thereby making it a course that appears on their transcript. Further, understanding to what extent students experience challenges in research and how they navigate them would provide institutions with ways to create more inclusive experiences for these students.

**<u>Current study</u>**

[2] We use the broad term Disability Resource Center (DRC) to describe offices on college campuses that are designed to support students with disabilities. Some institutions have other names to describe these offices, such as disability support services, accessibility services, student access centers, and accommodation resource offices.

To address the current gaps in the literature, we conducted two studies to understand (1) how common it is for students with disabilities to do undergraduate research and (2) what their experiences are like once they are in undergraduate research. Our studies were guided by the following research questions:

**Study I:**

(1) To what extent are students with disabilities participating in undergraduate research experiences?

**Study II:**

(1) What are the unique challenges that students with disabilities experience in undergraduate research?

(2) How do students with disabilities navigate challenges in undergraduate research?

(3) What are the unique benefits that students with disabilities experience in undergraduate research?

(4) Are there unique ways in which students with disabilities contribute to undergraduate research?

**Theoretical models informing this work**

The *medical model of disability* was the predominant way of describing disability in the 20$^{th}$ century and considers disability to be a physical or mental impairment of the individual that has personal and social consequences (Oliver, 1996, 2013; Shakespeare, 2006). The medical model of disability suggests the limitations faced by people with disabilities as a primary result of their impairments. In contrast, the *social model of* *disability*, which emerged during the disabilities rights movement of the 1970's and 1980's, argues that disability is a social construct; an individual may have a functional limitation, or physical, mental, or sensory impairment, but what makes that individual have a disability is that opportunities are taken away due to the attitudes and structures of society (Barnes & Mercer, 1997; Charlton, 1998; Stone, 1997). The social model of disability has become the prevailing model of the 21st century used by disability scholars. While each of these models have their limitations, neither, in their extremes, are sufficient in truly describing the experiences of individuals with disabilities (Goering, 2010; Oliver, 2013; Shakespeare, 2006). Practitioners have argued that these models of disability can be synergistically considered in a pragmatic sense to describe the disability experience from the perspective of individuals with disabilities (Overboe, 1999; Toombs, 1995). Thus, in this research we have chosen to consider elements of both models when describing the experiences of undergraduate researchers with disabilities. Specifically, we consider students' experiences in research from the following perspectives:

- Medical model perspective: We use the factual information and the student's experience of living with different physical, sensory, cognitive, or affective functions than the majority of the population to understand how they perceive their disability interferes with or prevents them from engaging in undergraduate research.
- Social model perspective: We use the student's experiences of facing attitudes, structures, bias, stigma, and discrimination based on their different physical, sensory, cognitive, or affective functions to understand how the student perceives

societal structures or attitudes interfere with or prevent them from engaging in research.

Additionally, we use *cultural community wealth* as a framework to characterize the unique value of including students with disabilities in undergraduate research experiences. The cultural community wealth framework is derived from critical race theory for Communities of Color and suggests there is an array of knowledges, skills, abilities, and contacts possessed by underrepresented populations who survive and resist forms of oppression (Yosso, 2005). In this work, we examine what unique perspectives students with disabilities perceive they bring to undergraduate research and what distinct skillsets students with disabilities may possess that may be particularly beneficial in research.

## Methods

This study was approved by Arizona State University's Institutional Review Board STUDY00007247.

### *Study I Methods*

#### Survey development

In fall 2018 and fall 2019, we conducted a national survey of undergraduate researchers in the life sciences at research-intensive (R1) public institutions, research-intensive (R1) private institutions, master's-granting institutions, and primarily undergraduate institutions (PUIs). The survey generally asked students about their overall experience in undergraduate research. In addition, students were asked specifics about their undergraduate research experiences, such as the position of their primary mentor (e.g., graduate student, faculty member) and how many hours they spent in research per week. Students also answered general demographic questions, including a question about their disability status, which was analyzed for this study. The question specifically asking about disability status was developed by reviewing the literature on different ways that disability status has been collected (e.g., Cappa et al., 2015; Livermore et al., 2011; Verbrugge, 2016) as well as how organizations and agencies (e.g., NSF, NCES, CDC) measure disability. We drew from these existing surveys to create an inclusive question to collect disability status. Specifically, students were invited to select whether they identified as having a disability including a learning disability (e.g., dyslexia), a mental health/psychological disability (e.g., anxiety, depression, PTSD), a physical disability (e.g., cerebral palsy, spina bifida, dwarfism), a chronic health condition (e.g., cancer, diabetes, multiple sclerosis), visual loss (e.g., blind), hearing loss (e.g., deaf), or another disability which they were asked to describe. Students were invited to select which type(s) of disability/disabilities applied to them and could select more than one that applied. Notably, this question did not require students to be diagnosed in order to identify as having a disability, since access to healthcare can vary based on student demographics such as gender, race/ethnicity, and socioeconomic status (Adler & Rehkopf, 2008; Baeten et al., 2018; Sommers et al., 2017; Thompson et al., 2016) and we did not want to bias our sample in ways that privilege those who have access to mental healthcare. Cognitive think-aloud interviews were performed with two undergraduate researchers to test the validity of the questions on the survey based on verbal reports of individuals' thought processes (Trenor et al., 2011). The survey was iteratively revised based on student responses in each think-aloud interview. The survey was then piloted with undergraduate researchers at a large public research-intensive (R1) institution in the Southwest. A copy of the questions analyzed in this study are provided in **Appendix D**.

**Student recruitment**

In fall 2018, we used the Carnegie classifications to identify all public R1 institutions in the United States. We used the university websites to identify individuals in life sciences departments who would be able to send an email to all undergraduate students via a listserv or mailing list (e.g., undergraduate program manager). We then contacted all 81 public R1 institutions with a personalized email to request that they forward our survey announcement to their students. Twenty-five (31%) public R1 institutions agreed to send the survey out to students in their respective life sciences departments. In fall 2019, we expanded our survey recruitment to other institution types. We repeated a similar process of using Carnegie classification to identify private R1 institutions, master's-granting institutions, and primarily undergraduate institutions as well as points of contact in life science departments to forward our survey. We contacted a total of 37 private institutions, 12 of which agreed to send the same survey out to students in their department (32%), 350 master's-granting institutions from which 30 (9%) agreed to send out the survey, and 241 primarily undergraduate institutions from which 20 (8%) agreed to send the survey out to students in their life science department. In total, we recruited from 87 institutions. Students were incentivized to complete the survey by being entered into a drawing to win one of four $50 gift cards each term. Our recruitment method was intentionally not done through DRCs because we wanted to be able to capture the experiences of students with disabilities who may not be registered with a DRC or who may not have had the health insurance or finances required to be formally diagnosed with their disabilities. Further, we intentionally did not recruit from a specific program (e.g., NSF REU program) because these programs often have greater levels of support and mentorship through a cohort model than traditional independent research experiences, and we wanted to be able to have representation from undergraduates who are not necessarily in these types of programs.

**Survey data analysis**

Of the students who reported having a disability, we used descriptive statistics to calculate and report the general demographics and research characteristics of these students. To contextualize our finding, we compared them to results from national surveys assessing the representation of individuals with disabilities in the general U.S. population (Centers for Disease Control and Prevention, 2018) and life sciences majors (National Science Foundation, 2016). In order to compare the representation of individuals with disabilities among different populations, it is important to note that how the term disability is defined and measured in each survey. We found that the definition and measurement of disability varied based on the organization that collected the data, which can affect conclusions that are drawn from these data. For example, the percent of the U.S. population with a disability is calculated by the Centers for Disease Control, which classifies disability as a condition that affects mobility, cognition, independent living, hearing loss, vision loss, and self-care; it is unclear, for instance, how mental health disabilities would be categorized within this organizational schema (Centers for

Disease Control and Prevention, 2018). For the NSF's 2016 undergraduate enrollment data, they consider disability as "blindness, deafness, severe vision or hearing impairment, substantial limitation of mobility, or any other physical, mental, or emotional condition but restrict this to a timeframe of having the condition within the last six months" (National Science Foundation, 2016). By not explicitly including mental health disabilities and requiring a particular timeframe that an individual has been affected by their disability, the CDC and the NSF may, at times, be underestimating the number of individuals with disabilities.

### ***Study II Methods***

#### **Interview recruitment**

At the end of the survey described in Study I, we asked if students would be interested in participating in follow-up interviews about their experiences in research. In summer 2020, we contacted all students with disabilities who participated in the 2018/2019 survey asking them if they would be interested in participating in an interview about their experience as an individual with a disability in undergraduate research. A copy of the recruitment email can be found in **Appendix D.** Students were offered a $15 gift card as an incentive to participate in the interview. Of the 152 students with disabilities who completed the survey in Study I, 20 undergraduate researchers with disabilities (13%) from eight institutions agreed to participate in the interviews.

#### **Interview protocol**

The interview script was developed to explore the overall experiences of students with disabilities in undergraduate research and align with our research questions.

Specifically, the interview questions asked students about 1) the extent to which they encountered challenges with conducting their undergraduate research, 2) what solutions or accommodations, if any, were helpful in navigating challenges in their undergraduate research experience, 3) whether they perceived they uniquely benefited from conducting undergraduate research as a researcher with a disability, and 4) whether they perceived there were any unique contributions they brought to the undergraduate research context given their experience as an individual with a disability. To ensure that each question would be interpreted correctly by our interviewees, we completed two think-aloud interviews with students with disabilities who had previously conducted undergraduate research (Trenor et al., 2011). The interview protocol was revised upon conducting the two think-aloud interviews. These students had engaged in undergraduate research prior to COVID-19, however the interviews were conducted during the COVID-19 pandemic. As such, we specifically asked students to consider their time in undergraduate research prior to the pandemic. A complete copy of the interview protocol can be found in **Appendix D**.

**Interviews and post-survey**

All interviews took place during summer 2020. The interviews were semi-structured, meaning that all students were asked the same set of questions, but additional follow-up questions were asked to allow students to elaborate on interesting ideas (McIntosh & Morse, 2015). It is also important to be attentive to the needs of individuals with disabilities who participate in research studies, particularly qualitative research (Kroll et al., 2007). As such, our recruitment email and reminder asked students if they needed any accommodations for participating in the interview to maximize the accessibility of the interview process. The interviews were conducted via Zoom, audio-recorded, and ranged from 45-60 minutes in length. The interview audio files were transcribed for qualitative analysis. To protect the identities of the participants, we assigned each person a pseudonym. The quotes from students were lightly edited for clarity, consistency, and anonymity. After the interviews were complete, students were given a brief follow-up survey asking about demographic information. The follow-up survey also included questions that were specific to the student's disability, such as whether they were formally diagnosed and whether they were registered with their university's DRC. A copy of the post-survey can be found in **Appendix D**.

**Interview analysis**

We used inductive coding methods to identify themes from the interview data (Thomas, 2003). First, two authors (L.E.G. and D.A.P.) reviewed the same five randomly-selected interviews independently and took detailed analytic notes to identify initial themes in the data. These interviews and notes were used to develop an initial codebook. Once the initial codebook was developed, the same two researchers reviewed a different subset of five interviews independently to determine if the themes in the existing codebook were present and whether additional themes emerged. After, the researchers met to revise the coding rubric. The revision of the codebook ensured that each code was distinct and independent of other codes; that is, the researchers checked that each portion (or unit) of a student's thought would be captured by a single code. Any overlapping themes were revised to make sure that units remained independent. The researchers also used constant-comparison methods to determine that quotes within the same theme were not too different from one another to merit creating an additional theme (Glaser, 1965; Glesne & Peshkin, 1992). Once the final codebook was agreed upon, the two researchers independently coded a new subset of five interviews (25%) to establish inter-rater reliability (Cohen's $\kappa = 0.89$) (Landis & Koch, 1977). One researcher (L.E.G.) coded the remaining 15 interviews. Because inferences about the importance of these themes cannot be drawn from these counts, they are not included in the results of the paper (Maxwell, 2010), but are provided in **Appendix D** along with the final codebook describing each theme.

**Student demographics and disability information**

All students in this study self-identified as having at least one disability. We used a previously-developed organizational schema to categorize students' disabilities throughout the paper (Gin et al., 2020). Students' disabilities were categorized as learning disabilities (e.g., autism, dyslexia), physical disabilities (e.g., cerebral palsy, spina bifida), chronic health conditions (e.g., cancer, diabetes), vision loss, hearing loss, and mental health and psychological disabilities (e.g., anxiety, depression). There is some disagreement in terms of how to categorize certain types of disabilities (e.g., autism and attention-deficit/hyperactivity disorder as learning disabilities), as well as the overlapping nature of certain disabilities and categories (Budd et al., 2016; Mayes et al., 2000). Additionally, the personal experiences of individuals are unique; even if two people have the same type of disability, the severity of the condition may differ or their personal or environmental situation may be different (S. Brown, 2002; Shakespeare, 2006). However, we chose to categorize students' disabilities in this way to preserve the confidentiality of students' specific disabilities or combination of disabilities, which may make a particular student identifiable especially in the context of undergraduate research experiences. We report each of the student's disabilities next to their pseudonym and their respective quote, but encourage readers not to make conclusions about any particular type of disability due to the small number of students with a given disability who were interviewed. A list of the types of disabilities reported by each student and their pseudonym can be found in the **Appendix D**.

**Researcher positionalities**

The first author (L.E.G.) has a physical disability and conducted all of the interviews for this study. He disclosed his disability to all students who participated in interviews in an attempt to establish rapport and create a welcoming environment for the student to discuss their experiences (Kvale, 1996). This author also developed the rubric and coded the interviews. Another author (D.A.P.) who helped develop the coding rubric has a close family member with a developmental disability. These two researchers used their personal experiences with disability to inform the coding rubric and analysis while also attempting to counteract any potential biases that they may hold (Chenail, 2011). The researchers used the interviews as an opportunity to learn from the lived experiences of those with a range of disabilities (Toombs, 1995). All members of the research team have currently, or previously, conducted either undergraduate or graduate research in life sciences as well as science education research, so there is an understanding of the dynamics of research experiences in the life sciences.

## Results and Discussion

For both studies, we chose to present our results and discussion together to contextualize the findings in the literature.

### *Study I*

**Finding 1: Students with disabilities are likely underrepresented in undergraduate research.**

In our national survey of 1,262 life sciences students engaging in undergraduate research across 25 public R1s, 12 private R1s, 30 master's-granting institutions, and 20 PUIs, 12.0% of respondents (n = 152) reported having a disability. This percentage indicates that individuals with disabilities are underrepresented in undergraduate research compared to the approximately 18% of students with disabilities who are pursuing undergraduate degrees in the life sciences (National Science Foundation, 2016) and the 26.0% of the U.S. population of individuals who identify with having disabilities (Centers for Disease Control and Prevention, 2018) (**Figure 5-1**). Undergraduate research is typically a robust predictor of whether individuals choose to pursue careers in science (Hernandez et al., 2018; M. T. Jones et al., 2010; Russell et al., 2007; Schultz et al., 2011). Despite the differences in how each agency that collects data on individuals with disabilities defines having a disability (see *Part I: Survey data analysis* section for details), we feel confident in concluding that individuals with disabilities are underrepresented in undergraduate research in the life sciences given the data collected in this study. The primary difference between our definition of disability and those used by the CDC and NSF is that our definition explicitly included students with mental health disabilities to be as comprehensive as possible. If we were to remove individuals who report mental health disabilities from our data, we would have even greater underrepresentation of students with disabilities (5.0%, n = 63) participating in undergraduate research.

***Who are the students with disabilities participating in undergraduate research?***

The students with disabilities engaging in undergraduate research reported a variety of different types of disabilities with mental health (58.6%) and learning disabilities (24.3%) being the most prevalent. Notably, 33% of students selected more than one disability. The majority of students were women (78.9%), white (67.1%), and continuing-generation college students (75.7%). Students varied in their year in school with most students being in their fourth year (44.1%). Students' ages ranged from 18-47 and averaged 22 years old. The average grade point average was 3.54. Only six (3.9%) students reported that they were associated with the U.S. military.

Regarding students' research experiences, most reported spending 6-10 hours per week doing research (47.4%) and had engaged in research for 1-2 years (41.4%). Students were primarily mentored by a Principal Investigator (PI) (44.1%) or a graduate student (28.9%). Most students received course credit (69.7%) for participating in their research. Finally, students were attending a variety of institution types, including primarily undergraduate institutions (11.8%), masters-granting institutions (14.5%), and research-intensive private institutions (19.7%), with from the highest number of students coming from research-intensive public institutions (53.9%). **Table 5-1** summarizes the student demographics, research demographics, and disability-specific demographics for the national sample of student researchers with disabilities.

### *Study II*

**Participant demographics**

Twenty students with disabilities participated in our interview study about their experiences in undergraduate research. The demographics of our interview sample generally reflected the demographics of our national survey sample of students with disabilities. Students in the study represented different types of disabilities including mental health (55.0%), learning and/or psychological (50.0%), chronic health conditions (25.0%), hearing loss (20.0%), and physical disabilities (10.0%). No students in our interview sample reported vision loss. Forty percent of students reported more than one disability. Ninety percent of students were medically diagnosed with their disability, and sixty-five percent were currently registered with their university's Disability Resource Center.

The majority of students who were interviewed were women (70.0%) and continuing-generation college students (80.0%). It is worth noting that the majority of students who we interviewed were white, yet the proportion of white students in the interview study was lower (55.0%) than that of the survey (67.1%). Twenty percent of the students who were interviewed identified as Asian/Pacific Islander, fifteen percent were Hispanic/Latinx, and no students in the interview study identified as Black or African American. The age range for students in the interview study was 18-29, averaging 21 years old. The average grade point average was 3.37, which was slightly lower than the survey sample. One student reported that they were associated with the military.

Most students spent 2-3 years in their research experience (35.0%) at the time of the interview. Participants most commonly reported engaging in research for 6-10 hours per week (40.0%) and were primarily mentored by a PI (30.0%) or graduate student (25.0%). Students attended primarily undergraduate institutions (10.0%), masters-granting institutions (15.0%), and research-intensive private institutions (20.0%), with the most students attending research-intensive public institutions (55.0%).

**Finding 1: Students with disabilities experienced unique challenges in undergraduate research.**

***Students reported challenges related to their disability that can make it difficult for them to carry out specific research-related tasks***

Nearly all students in this study referenced personal challenges related to their disability that prevented them from fully participating in their undergraduate research experiences. Specifically, students described that the symptoms or effects of their disability impeded their ability to focus on, conduct, or complete research-related tasks. For instance, Amy, Judith, Caroline, Michael, and Albert described how their disabilities can affect their productivity in research.

> Amy (chronic health condition, mental health disability): “During a flare up [an instance where symptoms related to the disability/disabilities are exacerbated], I have zero productivity. But when I don't have a flare up, then I can be at like

100% productivity. I wouldn't say it's like this overwhelming negative effect, but there still is that disadvantage."

Judith (mental health disability): "Some days [in research] were just way less productive than others because I was depressed or because I was anxious, because I couldn't sit still. There's been a couple of times where I've been doing an observation session, and I'll just completely space out because my heart rate is so high, for just literally no apparent reason."

Caroline (learning disability): "To do any experiment, we had to calculate a certain amount of cells. And occasionally, I would mess up that calculation. (…) It affected the research, and I thought that I was getting good results where those results don't even matter because I did the math wrong."

Michael (mental health disability): "It's harder to think quickly on your feet when you're battling an anxiety disorder plus trying to make the quickest informed decision."

Albert (learning disability): "Tedious [tasks] as in counting the [model organism], I guess would be the only place where my ADHD affected me. It's a pretty tedious task and requires a lot of focus, and in that case, I'd say ADHD might have affected me in my ability to do that."

Students with disabilities also commonly highlighted that when their disabilities negatively affected their ability to do research, they needed to repeat or make up missed work, which often increased the amount of time that they had to spend on research and slowed down their progress. For example, Judith continued on to explain how she had to repeat observations when her disability interfered with her attention span.

> Judith (mental health disability): "I'd have to restart the observation session. I was there doing the observation longer."

Amy highlighted that when her disability negatively affects her productivity in research, she often feels pressure to catch up by working without breaks.

> Amy (chronic health condition, mental health disability): "If I have like a day or two where I have a flare up and I can't physically work, then it's like the next day I have to compensate and sit there for six hours instead of taking a break."

Further, Michael described how his disability causes him to spend more time in research than his peers.

> Michael (mental health disability): "I think I spend a lot more time than my colleagues [in research], double, triple checking and whether that's just because I'm trying to conduct very proper research versus anxiety, that line gets blurred every once in a while. But I definitely noticed myself doing things more often and just a lot more double and triple checking, a lot of worrying."

Needing to work for extended time periods and working without breaks can lead to burnout, defined as a work-related chronic stress syndrome involving feelings of cynicism, emotional exhaustion, and reduced personal accomplishment (Bianchi et al., 2014; Koutsimani et al., 2019; Maslach et al., 2001). Studies have shown that individuals who experience burnout are likely to later report a disability (Ahola et al., 2009), and burnout has been shown to be significantly associated with some mental health disabilities, namely anxiety and depression (Koutsimani et al., 2019). However, the students' experiences in our study indicate that undergraduate researchers with disabilities could be at risk for experiencing burnout if they feel they need to compensate for delayed or disrupted research related to their disability (Toppinen-Tanner et al., 2005), which could lead to a recurring cycle of non-productivity and heightened mental stress (Abramson et al., 1989; Murphy et al., 2007).

Based on our interviews, it is evident that students often resort to adopting the medical model of disability perspective when conceptualizing the relationship between their disability and research productivity. Specifically, they often describe their disability as a functional limitation resulting in an impairment, preventing them from completing a certain task (Brisenden, 1986). For example, Caroline, Judith, Amy, Michael, and Albert all described how their disability prevented them from engaging in research. During the interviews, students rarely described their challenges from the social model perspective. Considering the social model would identify societal norms, attitudes, or structures that prevent a student from engaging in an aspect of research given their disability (Oliver, 2013; Siebers, 2008; Sins Invalid, 2019). However, some students did recognize how the societal norms of science, such as expecting everyone to read dense research papers, may have historically excluded individuals with disabilities from fully engaging in science. For example, Rebecca highlights that providing her with a summary of a paper would significantly shorten the time she needs to spend reading, given her disability.

> Rebecca (learning disability): "Well, the sad part for me about science research is that everything you do, you have to read. (…) For me that's probably the toughest

part about research. It has taken me so long to get caught up to where I need to for a level of understanding that it's been a disadvantage. [People] you work with get angry, but they get frustrated because they're like, 'Why haven't you read this paper? You need to understand this going forward.' I'm like, 'If you could literally just summarize it for me, we would be so good.' I read slower. Something that would take the average person 20 minutes to read- I'm there an hour and a half later being like, 'I'm still halfway through.'"

Encouraging both students with disabilities and members of research labs, including PIs, to view the experiences of students with disabilities through a social model perspective is an important step toward creating a more accessible scientific community. For example, had Rebecca's research mentor showed her how to listen to a scientific paper, or to first try to interpret the figures, this may have created a more positive experience for her. Identifying ways that the traditional process of doing science can change, as opposed to how students with disabilities should mold into the traditional process of science, is an important step to creating a more inclusive scientific community (Brown & Leigh, 2018; Peterson, 2021).

***Undergraduate researchers with concealable disabilities experienced unique challenges related to whether they reveal their disability or not in undergraduate research***

Some disabilities are apparent or visible while others are non-apparent or invisible (Kranke et al., 2013). There is general stigma around having a disability (Fine & Asch, 1988), and as such, students who have non-apparent or invisible disabilities have concealable stigmatized identities or CSIs (Joachim & Acorn, 2000; Quinn et al., 2014; Quinn & Earnshaw, 2011). CSIs are identities that can be kept hidden or concealed from others and that have negative stereotypes attached, which can result in a loss of status and/or discrimination in society (Link & Phelan, 2001; Quinn & Earnshaw, 2011). Students who had disabilities that they described as non-apparent or invisible reported experiencing unique challenges relating to their disability and whether they choose to reveal it in the context of undergraduate research.

Students discussed how they often chose not to disclose or discuss their disability with members of their research group. Some students, such as Wanda, experienced instances where a stigma about disability was present in their conversations with other members of their research group, which discouraged them from revealing their disability.

> Wanda (learning disability, mental health disability): "I was working on the countertop and my mentor was talking with somebody else. They were talking about people with ADHD and how they have to rely on their parents and they don't know how to do anything and they can't work. I'm thinking like, 'I can work, I'm working for you.' I didn't say anything, but I was shocked that he said that about the whole population and he didn't know what I had."

In addition to students feeling that disclosing their disability could result in others doubting their abilities, some students, such as Cornelius, mentioned that they did not disclose or discuss their disability because they did not want it to result in any questioning about their ability to perform specific research-related tasks, such as writing, analyzing data, or problem-solving.

Cornelius (chronic health condition, learning disability, mental health disability): "If people talk about disabilities [in the lab], I don't usually say that I ever had an IEP [Individualized Education Plan, a document that lays out education instruction, supports, and services for K-12 students with disabilities (Pretti-Frontczak & Bricker, 2000)] or anything. And I probably don't feel comfortable telling my PI because she's a little scary. (...) I know a lot of research involves writing and they always say strong writing is highly required. And I'm like, 'Oh [expletive].' The ability to communicate is really important because I know those are the parts more affected by my disability."

The experiences of Wanda and Cornelius echo studies suggesting that individuals with CSIs often assess the beliefs of those around them before revealing their identity (K. P. Jones & King, 2014). If there is an indication that someone in one's research group may not be accepting of their identity, then they are unlikely to reveal their own identity (Barnes et al., 2020, 2021; Cooper, Gin, & Brownell, 2020). Additionally, Cornelius' experience is further supported by studies that have shown that both undergraduate and graduate students with depression often choose to conceal their depression from their PIs in particular because they fear that revealing this aspect of themselves would result in research responsibilities being restricted, even though students who do reveal their depression to their PIs do not report any loss of responsibilities (Cooper, Gin, & Brownell, 2020). However, one student in the current study, Michele, did reveal her CSI and highlighted how she was left out of experiments and collaborations once others knew of her disability.

Michele (chronic health condition, mental health disability): “Even when I'm getting notes from my neurologist, [people in my lab] just treat me like, ‘Well everybody has headaches. Why can't you do this?’ I would just say that I feel like sometimes I'm treated like I can't do things as well as other people or like I'm just not reliable instead of actually having problems. I’m not being picked for certain experiments and certain people don’t want to collaborate and work with me because [they know about my disability].”

Some students who had self-described more apparent disabilities discussed how they at times downplayed their disability. They explained that if they concealed their disability, at least at first, others would be more likely to believe it did not affect their research performance. For example, Gabriella describes hiding her hearing aids and monitoring her speech so that others in her lab do not notice her disability.

Gabriella (hearing loss): “I wear my hair down [to hide my hearing aid]. [I also try to be mindful of] my voice. My mom says I talk like a deaf person. I think it does give it away a little bit, but only to people who know, like doctors.”

Feeling the need to conceal one’s disability in research can be detrimental to students for multiple reasons. First, concealing an identity can lead to psychological distress and take an emotional toll on students (Goffman, 2009; Mak et al., 2007; Quinn et al., 2014; Quinn & Chaudoir, 2009). Specifically, individuals who conceal an identity may worry about someone revealing their identity when they did not want it to be revealed, when they may need to reveal that identity, and what may happen when others learn about the given identity, all of which can lead to further internalized distress (Link

& Phelan, 2001; Quinn & Chaudoir, 2009; Quinn & Earnshaw, 2011). Additionally, experts on mentorship assert that effective mentorship requires an understanding of identity-related challenges students face, so that mentors can help better meet the needs of their mentees (National Academies of Sciences & Medicine, 2019). As such, we encourage lab mentors to be mindful about what they say regarding student identities, including disabilities, and to work to create an inclusive environment where students can feel comfortable revealing their disability if they choose (Cooper, Gin, & Brownell, 2020). A student feeling comfortable in discussing their disabilities with lab members is likely a key step in identifying ways to make the research environment more inclusive (Chaudoir & Fisher, 2010).

**Finding 2: Students with disabilities navigate undergraduate research experiences by finding unique solutions to the challenges they experience.**

***Few students reported that they have received formal accommodations in undergraduate research through their university's Disability Resource Center***

Traditionally, when students with disabilities are enrolled in university courses, they work with DRCs to provide accommodations to make learning environments more accessible (Feldblum, 1996; Madaus, 2011). If a student is enrolled in undergraduate research for course credit, as is the case for 65.0% of the students who were interviewed in this study, then technically they should have the same access to the DRC and accommodations as they would any other course at their university. However, most students who were interviewed, like Skylar and Anita, did not think that they could ask about accommodations for their undergraduate research experience through their university's DRC.

> Interviewer: "Are you aware that if you are enrolled in research for credit, you may be eligible for accommodations through the Disability Resource Center?"
>
> Skylar (learning disability): "No, I didn't know that. And I didn't even think about it."
>
> Anita (learning disability, mental health disability): "I haven't [sought accommodations in research], just because I didn't think that was a thing."

Given recent research that has unveiled that DRCs typically do not have blanket accommodations for modified learning environments, such as active learning or online courses (Gin et al., 2020, 2021; Meeks & Jain, 2015), we hypothesized that many DRCs may not be equipped to provide accommodations for students in undergraduate research experiences. Interview participants, such as Albert, also expressed doubt that the DRC would be able to accommodate their needs in this unique context.

> Albert (learning disability): "Honestly, I don't know what kind of accommodations would even be available for people with ADHD in research. And so, if I had [thought that my DRC had accommodations I could use] I guess I might have looked into it."

It is not clear to what extent DRCs are aware of students with disabilities who are engaging in undergraduate research and their need for accommodations. However, some standard classroom accommodations could be used or adapted to an undergraduate research setting. For example, students with a disability that typically requires a notetaker in a lecture classroom may need one-on-one research meetings or lab meetings to be recorded and transcribed. This could be particularly helpful if a mentor is describing how to do a complicated step-by-step procedure that the student with a disability would need to do on their own in the future. An alternative accommodation may be to have another undergraduate researcher work closely with them on their project and help take notes for them. For common lab techniques, the lab could be asked to create detailed written protocols available for everyone in the lab. Another common standard classroom accommodation is extended time for testing or assignments. For students who need extra time to complete assignments, an accommodation in the research lab may be longer timeframes to complete tasks or more advanced notice about an experiment or task. While this may slow the pace of the research, not feeling rushed will likely result in better research products and may prevent mistakes. Finally, excused absences are often provided to a student whose disability is interfering with their ability to come to class; this accommodation can be administered in a research environment by providing flexible work hours and allowing lab members to work from home if the task allows it. While students and mentors could likely arrive at some of these solutions on their own, having the DRC facilitate accommodations can take the burden off of the student to voice their needs and decrease the time it takes for students to receive the accommodation (Gin et al., 2020, 2021; Meeks & Jain, 2015; Pfeifer et al., 2020, 2021).

***Undergraduate research experiences require that students with disabilities self-advocate to maximize their experience in research; most accommodations are developed on an individualized basis between the student and the research mentor***

No student who was interviewed reported using their DRC to provide accommodations in research, however nearly all students who dealt with disability-related challenges in their undergraduate research experiences needed to self-advocate in order to mitigate their challenges. Self-advocacy involves voicing access needs and concerns in order to identify potential access solutions (Eckes & Ochoa, 2005; Test et al., 2005). Studies have shown that undergraduate students with disabilities may find it challenging to self-advocate, particularly in science, as they navigate interactions with instructors, peers, and DRC support staff (Pfeifer et al., 2020). For some students, like Hugh, self-advocacy comes in the form of making mentors aware of his disability to help ensure his safety in the lab and explaining how his disability may affect his overall experience in undergraduate research.

> Hugh (chronic health condition, hearing loss, learning disability, mental health disability, physical disability): “I have to advocate a bit more than anyone would normally have to personally advocate for themselves to make sure that they're just getting what they want out of the experience and making sure that they have a positive experience. I need to make sure that I can go to [medical] appointments when need be and I need to advocate for myself and say that if I'm working in a BSL-2 [Biosafety Level 2] space to be really safe about it so I don't get too sick with it or get too sick while doing the research.”

Other students used self-advocacy to foresee potential issues that may arise in their research experience. Students, like Temple, described that being upfront about their disability and what they need can help prevent misunderstandings, because otherwise a research mentor may not understand a certain situation for a student with a disability in research.

> Temple (learning disability): “I try to always actively talk about what I need [in research]. If I think it's going to be an issue, I try to never assume that [my mentor] is going to know not to put me in a situation or not to ask me to do something when I can't do that. I try to be clear to avoid problems later. I do feel like I always need to personally advocate because otherwise somebody is not just going to get it.”

Students who self-advocated often found solutions through working with their mentors. For example, Anita, Tia, and Rebecca did not use the DRC for accommodations, but did work with their mentors to provide accommodations for their research experiences. It is worth noting that many of the solutions that students and mentors agreed upon can be relatively simple to implement, such as being flexible with a student’s schedule or providing written instructions or pictures to students.

> Anita (learning disability, mental health disability): “My grad student does his version of accommodations where he basically gives me notes for what he needs me to do. And then he’ll specifically also give me a list of instructions and stuff that he says to lay it out for me. Just to make it a little bit easier for me to remember things.”

> Tia (hearing loss, mental health disability): “I started asking for pictures and figures instead of for things to be written out which was a huge help. It led to me making a lot of [concept] maps that were interesting but also equally useful that I

don't think that we would have even thought about using those for communication before."

Rebecca (learning disability): "The level of patience [my research mentors] have had is one of the best accommodations that I could have. They understand what takes [another undergrad] like a week to do, it's going to take me two weeks. When we come to like, 'Do we need to push the meeting?' I'm like, 'We need to push the meeting.' Having that level of patience and saying like, 'It's okay, it happens.' That's been really nice."

In addition to self-advocating with mentors, student researchers with disabilities also described self-advocating with their lab mates. Lab mates knowing about a student's disability and their needs may help facilitate efforts to maximize a student's experience in undergraduate research (Quinn et al., 2014; Quinn & Earnshaw, 2011). For example, students like Naomi discussed that other members of her lab were able to check in with her to see how she was doing and if she needed anything after she had talked to them about her disability.

Naomi (physical disability): "I needed to take a break during fieldwork, [the people in my lab would] be like, 'Okay, do you want me to take over what you're doing or you want to just go take a break together?' They were very supportive and just, 'Hey, if you need help, just let me know.' It created a family-type situation."

Studies have shown that individuals with depression have also noted that once they disclose this CSI, their lab mates are more likely to support and check in on them

(Cooper, Gin, & Brownell, 2020). Studies have also shown that students who disclose identities are more likely to come in contact with similar others because disclosing one's CSI can lead to others disclosing a CSI if they have one (Quinn et al., 2014). As such, self-advocacy can be a powerful, although sometimes draining (Hong, 2015; Lynch & Gussel, 1996; Pfeifer et al., 2021; Test et al., 2005), way for students to access accommodations and the resulting benefits.

***Students also relied on their own creative solutions to maximize their research experiences***

In addition to students working directly with their mentors and lab mates to maximize their research experience, some students discussed creating their own solutions to challenges that they encountered in their research experience. Because students with disabilities are experts about how their disabilities affect them based on their own lived experiences with their disability (Toombs, 1995), some talked about how they would adapt to potential barriers that their research environment posed. This is illustrated by Naomi and Katie who both developed unique ways to adapt to challenges.

> Naomi (physical disability): "I'm clicking with the mouse a lot because it's taking measurements on the computer. So, it's just finding a comfortable position to rest my arm. Otherwise, it gets stiff. My wrist gets uncomfortable."
>
> Katie (hearing loss): "I would try and position myself like on [my mentor's] left side so I could hear her. I would take lots of notes when she was trying to explain some sort of process so I could make sure I didn't miss anything."

As Naomi and Katie describe, they are often having to adjust to societal standards and structures that may not be suitable for those with disabilities, which can be both physically and emotionally taxing. Such standards and structures have been built on a history of ableism that were not created with individuals with disabilities in mind, whether students themselves realize it or not (Goodley, 2014; Peterson, 2021). The juxtaposition between students with disabilities working with mentors to change something about the structure of the lab or the behavior of people within the lab and students with disabilities changing their own behavior to maximize their experiences as someone with a disability in research reflect the social and medical approach to disability, respectively (Brisenden, 1986; Shakespeare, 2006). Considering the social model of disability, the mentor or lab mate recognizes that the way research is being conducted is excluding the students from participating. In contrast, a student with a disability who changes their own behavior reflects an assumption (perhaps of their mentor or lab mate) that their disability limits what they can do in research. Previously our research group has argued that developing accommodations on an individual basis will meet the unique needs of the student, but that it often takes longer and requires the student to encounter a problem before an accommodation is offered (Gin et al., 2020). The wasted time spent encountering the problem and responding to the problem may be sufficient to derail that student from persisting; in some cases, the problem may never be addressed. Thus, we urge future research to explore what, if any, accommodations are available and scalable in hopes of identifying standardized accommodations that would allow students to be supported before they encounter the challenge. Some of these solutions may be difficult for individual mentors to provide for students because a lab may not have the funding or resources available to assist the student (e.g., adaptive equipment, software, or technologies). Therefore, it would become increasingly important to have assistance from outside sources, such as the department, the university's Disability Resource Center, or national funding agencies, to better accommodate students with disabilities in research. As universities are required to accommodate students (Americans with Disabilities Act of 1990, 1990; ADA Amendments Act of 2008, 2008; Section 504 of the Rehabilitation Act, 1973), policies need to be in place so that a lab mentor can know who to go to for funds for these accommodations.

### Finding 3: Students with disabilities reported distinctive benefits from participating in undergraduate research.

Studies have shown that on average students benefit from engaging in undergraduate research (National Academies of Sciences & Medicine, 2019; Russell et al., 2007; Seymour et al., 2004; Thiry et al., 2012), but we wanted to examine whether students perceived that they reap unique benefits from research given their disabilities.

#### *Undergraduate research can counteract the narrative that students with disabilities cannot do science or enter scientific careers*

Systemic ableism has resulted in few examples of scientists who identify as having a disability, so students with disabilities often lack role models in science who may be able to provide them with navigational capital and advice for how to pursue a career in science (Cooper, Gin, & Brownell, 2020; Listman & Dingus-Eason, 2018). Further, the absence of role models, coupled with the often hostile environment in science for individuals with disabilities (Dunn et al., 2012) can erroneously present a narrative that individuals with disabilities cannot pursue careers in science. This perceived identity incompatibility has been shown to be a factor in the attrition of science students (Good et al., 2012; Rosenthal et al., 2011, 2013). As such, bolstering the confidence of students with disabilities to counteract that narrative of their ability to do science may be integral to promoting retention among these students (Adedokun et al., 2014; Daniels et al., 2016). When students in this study were asked about their confidence in their ability to do science, they often described that their confidence before they started research was low because it was based on their sometimes poor performance in traditional lecture courses. Yet, studies have shown that these undergraduate courses are often inaccessible for students with disabilities and may not accurately reflect their ability to do science (Braun et al., 2018; Harshman et al., 2013; Mason & Hedin, 2011; McMahon et al., 2016). After conducting undergraduate research, some of these students felt for the first time that they could be a scientist. For example, Odette and Tia highlight how their experiences conducting undergraduate research disrupted their initial impressions of their abilities to do science.

> Odette (learning disability, mental health disability): “My grades were not always that great (…) I would just flunk a test because I didn't understand what they were asking or I studied a graph that was different and then they laid it out differently. And I was like, I don't know how to read this, things like that. So, when all that would happen [in class], I would still be doing posters, writing papers,

participating in this research that I thought was really worthwhile and impactful. And it just made me feel like I can be a scientist."

Tia (hearing loss, mental health disability): "Because of the anxiety and the very bad situations with my math courses, I really thought that I wasn't going to be able to do any amount of research. [My PI] really helped me realize that as soon as I could put data in a table or in a graph, I could understand it better. I didn't even think [doing research] was a possibility and honestly is the reason that I want to do science now."

Overall, the reflections from Odette and Tia demonstrate that their experience in undergraduate research changed their confidence in their ability to do science because it demonstrated that they can be successful as a researcher. Doing undergraduate research allowed them to feel like they were actually "doing science," showed them that they could be scientists, and helped them in adopting a science identity (Hazari et al., 2013).

There is ample evidence that undergraduate research experiences can be career defining for students; for example, undergraduate research experiences are one of the best predictors for continuing on in research careers (Bauer & Bennett, 2003; Carter et al., 2009; Estrada et al., 2016; Russell et al., 2007; Seymour et al., 2004). However, for these students with disabilities who do not often see role models in science, undergraduate research experiences allowed them to disrupt their assumptions that they could not pursue careers in science and see themselves as future researchers. For students like Tia, her undergraduate research experience allowed her to recognize the value of doing research and showed her that it is a possible career path when she initially doubted her ability to succeed in research.

> Tia (hearing loss, mental health disability): “I definitely like to work with research and data collection, but also particularly fieldwork. I didn't even realize how important [undergraduate research] was to me until I got into research because I didn't think that I'd be able to do research. That seemed too academic and too, I don't want to say hardcore, but I thought that it was going to be too hard for me to deal with, and it turns out that it wasn't and that I actually flourished and I continue to want to seek it out [as a career].”

Jesse described working in a research lab that studied autism. Based on his experience as someone who identifies as autistic, he developed an understanding of some of the limitations of this research if it is not done by someone whose community is directly affected by the work. He also noted that he now knows what it is like to work in an accessible lab, which is something he will pursue in the future.

> Jesse (chronic health condition, learning disability): “I mean, [my undergraduate research] has definitely influenced what I want to do. I definitely want to continue to research autism, especially because I find that most of the research that's done on autism and autism spectrum disorders is research done on children predominantly and then people who are assigned male at birth, as opposed to people that are assigned female at birth, when it presents itself differently in every person. Wherever I work has to be accessible, otherwise I can't work there.”

While students with disabilities often enter undergraduate programs with the same level of interest in science as students without disabilities (Thurston et al., 2017), the completion rates and matriculation rates into advanced degree programs and science professions remains lower (BLS, 2020). As such, this finding highlights the important potential for undergraduate research experiences to have a positive impact on career choices for students with disabilities. In this case, undergraduate research can serve as work-based learning experiences that can be influential for individuals with disabilities (Bellman et al., 2014; Lave & Wenger, 1991). The ability to explore career options prior to joining the workforce can be particularly helpful for individuals with disabilities who may inaccurately assume that they cannot do a career like scientific research (Hershenson, 2005).

***Students with disabilities discussed that undergraduate research provides them with a unique context to build resiliency and overcome obstacles***

Failure, and particularly student response to failure, as well as fear of failure has been proposed to have implications for student attrition and retention to science programs (Harsh et al., 2011; Henry et al., 2019, 2021; Simpson & Maltese, 2017); specifically the use of maladaptive coping, or not being able to cope properly, has been shown to negatively affect an individual's well-being and also prevent the individual from making progress, finding a resolution, or moving beyond the initial failure (Carver et al., 1989; Henry et al., 2019; Skinner et al., 2003; Struthers et al., 2000). Conversely, students who experience "productive failure", defined as engaging students in unstructured, complex problem solving and challenging tasks that students know they may be unable to complete (Kapur, 2008; Kapur & Bielaczyc, 2012), can develop resiliency and behaviors that may help them successfully navigate future challenges in science (Gin et al., 2018; Henry et al., 2019, 2021; Skinner et al., 2003). Undergraduate research has been described as a potentially impactful way to teach students to deal with obstacles, setbacks, and failure (Auchincloss et al., 2014; Firestein, 2015; Gin et al., 2018; Henry et al., 2019). However, the failure inherent in research has been shown to be particularly difficult for some students, including students who have disabilities like depression (Cooper, Gin, & Brownell, 2020; Gin, Wiesenthal, et al., 2021), and we know of no studies that have examined how students with disabilities broadly navigate failure in the context of research.

Many individuals with disabilities face challenges in their everyday lives (Campbell et al., 1999; Koon et al., 2020). Studies have shown that while resilience is important for individuals with disabilities, it can be a challenging skill to build (Alschuler et al., 2016). However, individuals with disabilities who build resilience and overcome obstacles can experience a better quality of life, more overall satisfaction, and improved health benefits (Alriksson-Schmidt et al., 2007; Silverman et al., 2015). Thus, providing students with an opportunity to build resiliency to obstacles and overcome challenges in a context such as undergraduate research may have a positive broader effect on students with disabilities. Indeed, as Skylar and Naomi point out, their perseverance in undergraduate research, given their disability, has helped them overcome obstacles in other aspects of their life and made them proud of what they have accomplished.

Skylar (learning disability): "I think [doing research] means more for me than for other people just because the person with the learning disability is the only one who knows how hard it is. And to overcome that adversity [can help me] overcome other things as well."

Naomi (physical disability): "I have obstacles in my path, including with research. They're just there. I come with obstacles. So, I've just got to figure out how to get over them and always just a, 'Hey, that's just how it is.'[Doing research] makes me feel pretty proud, pretty happy. Of all the students that my professor could have asked, she knew I had a disability. She still asked me. So, it makes me feel pretty happy and pretty proud."

Students, like Temple, also highlighted how her experience in research altered the way she perceives failure, as well as how she reacts when others experience failure.

Temple (learning disability): "[Having a disability] does make me very determined. I think that aspect of motivation is obviously important because in research you need perseverance. Things rarely work out the first time the way you expect them to. But I've learned that achieving that end goal is something that I can push myself toward. I think a big thing is sort of altering my perspective toward mistakes and failure. I've learned how to be more accommodating to myself and more accepting to myself. And that also comes out in my interactions with other people. Somebody else makes a mistake I am also accommodating to them because I know that I am struggling with something, regardless of whether or not they are. A mistake is not enough to be angry at somebody."

Because these students experience challenges and/or failure in the context of undergraduate research, they have been able to gain new perspectives on how obstacles should be approached as well as become more understanding of others who may encounter difficulties in their research experiences. Although we present these examples because the students highlighted overcoming challenges and failure as a benefit of participating in research, there has been critique of asking students to persist through difficulties, some of which have been termed "grit" (Duckworth et al., 2007), and other research shows that failure can be very detrimental to students (Brunstein & Gollwitzer, 1996; Smith et al., 2006). As such, we want to acknowledge that we are not advocating for putting the burden on the student to persist and overcome the failure; mentors can provide students with projects with a lower likelihood of failure and sufficient guidance from a mentor can help students identify a mistake earlier in the process, help make sense of confusing patterns in the data, and even recognize when to give up on a project. In sum, we do not feel as though students with disabilities, or any student, require failing to become a scientist, but we do want to highlight how "productive failure" may be beneficial for some students (Kapur, 2008; Kapur & Bielaczyc, 2012).

**Finding 4: Students with disabilities recognize unique contributions they can provide to the research community, owing to their unique perspectives.**

Cultural community wealth describes the array of knowledge, skills, abilities, and contacts possessed by underrepresented populations that survive and resist forms of oppression (Yosso, 2005) and can be useful in considering how individuals with disabilities may bring new ways of thinking, new knowledge, and new skills into a setting such as undergraduate research (Huber, 2009; Liou et al., 2009). Cultural community wealth takes an anti-deficit approach of not identifying what is wrong with or missing from a group that has been oppressed, but rather what unique insights they can offer. In our interview study, we aimed to examine the ways in which students with disabilities add community cultural wealth to research experiences in the life sciences.

***Students with disabilities described bringing a unique perspective to research***

Students described that they felt as though their disabilities gave them unique viewpoints and perspectives that influenced the ways in which they approached their research. In particular, some students described that they were able to provide a unique lens for solving problems in science that they may not have otherwise had if it were not for their own lived experiences as an individual with a disability. For example, Hugh describes and considers his own disability and breadth of experience with medical doctors.

> Hugh (chronic health condition, hearing loss, learning disability, mental health disability, physical disability): "I think being able to use my own experiences with doctors or in the hospital, I think it gives me ways to look at problems differently and to ask different questions."

Moreover, Odette describes that her disabilities bring an advantage to research because of the overall diversity she brings to the scientific research community and the unique perspectives that she has as someone with a mental health and learning disability. She describes that she is able to "think outside the box" and has had other researchers tell her that they have not considered research problems or research questions in the same ways in which she may consider them. This is consistent with other arguments that consider individuals with disabilities to be some of our society's best forward-thinkers and problem-solvers because they encounter problems, obstacles, and challenges that require solutions at a greater frequency than those without disabilities (Emery, 2018; Joyce, 2019).

> Odette (learning disability, mental health disability): "I think [having a disability] gives me an advantage in that it brings more diversity to the table and it brings kind of a unique perspective I guess because I'm not always used to seeing what some people see inside the box, I just kind of like to think outside the box pretty freely. And so people have told me, I guess that... like some of the research ideas that I think about are things that they'd never really considered."

Additionally, some students mentioned that traits and characteristics related to their disability can provide an advantage in conducting certain research-related tasks. For example, as Tia describes, she feels as though her anxiety gives her better attention-to-detail, helping her avoid mistakes in the research process. Another common example, illustrated by Skylar, is that students with ADD described being able to hyper-focus on certain tasks such as data entry or data collection.

> Tia (hearing loss, mental health disability): "I definitely feel that my anxiety gives me better attention to detail. (...) The worry that I'm going to screw up so badly, it's helpful towards the research, it is detrimental towards myself in the way of making sure that I got everything done or that I would put in late hours to make

sure that the work that was asked of me got done, but it makes the research better."

Skylar (learning disability): "But a part of like ADD is that you can really focus on stuff, as well as not being able to focus on stuff. You can hyper-focus on certain tasks. (…) I'm able to hyper-focus on some things for long periods of time and then other times I just can't focus on anything."

These students' perceptions support the notion that including individuals with disabilities and their perspectives will diversify the scientific community, increase the objectivity of science, and reduce the amount of bias that may exist in scientific reasoning (Anderson, 2006; Intemann, 2009; Solomon, 2006). For example, scientific researchers get to select the research questions that are asked and answered, defining what is important to their discipline (Hrdy & Bleier, 1986; Wylie & Nelson, 2007). In addition, individuals with disabilities may also leverage their unique perspective to identify limitations of existing models and propose new ones, incorporate a fuller range of alternative hypotheses and interpretations of data, and open up new lines of evidence (Braun et al., 2018; Intemann, 2009). Moreover, individuals with disabilities bring community cultural wealth to their research experiences, which allows them to uniquely approach challenges in their research experiences, leading to additional benefits from conquering these obstacles (Yosso, 2005).

***Some students reported a greater sense of empathy and understanding for the process of research because of their experience with their disability.***

In addition to feeling as though they bring unique perspectives and experiences to undergraduate research, several students noted that they specifically felt as though they brought a greater sense of empathy and understanding to the research process, participants in research studies, and fellow researchers. This was often particularly true of students whose research experiences involved working directly with human research subjects. Jesse, who conducts autism research, describes that his own motivation for wanting to do research is because he feels as though he has insight into the disabled experience that can shape how he approaches his research. For example, he notes that he has his own personal experience with autism and how he thinks about others in his research.

> Jesse (chronic health condition, learning disability): “I wanted to do research [on autism] because I am disabled, and I know other people have different experiences, and I know that just because I experience something doesn't mean that everyone else with the same disorder does. But there's a lot of similarities and a lot of things that two people with the same disorder might both experience.”

Additionally, some students, such as Michael, noted that they feel more empathetic for their peers and other researchers within their research groups who may have disabilities.

> Michael (mental health disability): “I've tried to be more empathetic when working with other volunteers [researchers]. We have a volunteer who has autism in our lab. And I try to be more empathetic. It’s awesome and really great that we have him.”

There has been a broad critique of able-bodied individuals not being aware or understanding the challenges of students with disabilities (Dunn et al., 2012; Moon et al., 2012). One concrete benefit that could result from engaging more students with disabilities in undergraduate research experiences is the potential for them to serve as more culturally competent research mentors for students with disabilities, as future upper-level undergraduates, as graduate students, as postdocs, and as faculty members (Balcazar et al., 2009; Eddey & Robey, 2005). However, because of their own marginalized experiences, they may also be able to better mentor any student with a marginalized or stigmatized identity because of their enhanced empathy for being "othered" and potentially increase the belonging of students in other minoritized or underrepresented groups (Busch et al., Under Review).

**Limitations**

The students in both studies were recruited from life science undergraduate programs, and as such, there may be discipline-specific differences in student research experiences in the sciences. Future work should explore undergraduate research experiences in other science disciplines, as each discipline may present unique challenges for students. For example, some students in our study discussed their experiences with fieldwork or computation that may be unique to the life sciences. Additionally, our studies included students who primarily reported learning disabilities, mental health disabilities, and chronic health conditions and did not include any students who identified as having vision loss. Future research could take a targeted approach to recruit students who have specific disabilities that were underrepresented in this study. However, in general, our interview sample was relatively representative of our survey sample, indicating that studies examining what prevents students with particular disabilities from engaging in research may be a needed first step.

Similar to any interview study, it is possible that students in this study experienced social desirability bias where students may have given socially desirable responses to interview questions rather than responding with what was reflective of their true feelings (Grimm, 2010). This could be particularly concerning given that individuals with disabilities are a historically marginalized group who may be reluctant to identify their challenges or weaknesses (Logan et al., 2008; Merrill et al., 1997). Thus, individuals in our study may actually be underreporting and underestimating some of the challenges they have experienced in undergraduate research because of the hierarchical nature of research and concerns about anonymity. In addition, our conclusions are limited to students' perspectives. As such, we did not identify an exhaustive list of the ways students are challenged in, benefit from, or contribute to research. Additional interviews with stakeholders such as peers, research mentors, and DRC support staff would be needed to fully answer these questions.

## Conclusion

Together, our data suggest that students with disabilities are underrepresented in life sciences undergraduate research experiences, and students with disabilities who do participate in research report that they experience challenges specific to their disabilities. According to the students interviewed, these challenges seem to only be mitigated if students reveal their disability and self-advocate for accommodations or identify solutions themselves. However, in addition to the array of benefits that all students can gain from engaging in research (Adedokun et al., 2014; Bauer & Bennett, 2003; Daniels et al., 2016; Olimpo et al., 2016; Thiry et al., 2012), this work also suggests that students with disabilities may garner unique benefits by using undergraduate research experiences to counteract the narrative that they cannot pursue careers in research. Importantly, undergraduate researchers with disabilities highlighted ways in which they contributed community cultural wealth to undergraduate research, namely providing unique insights and being empathetic toward others. This work emphasizes the need to recruit undergraduate researchers with disabilities and retain them by providing more inclusive research environments.

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## Tables and Figures

**Table 5-1. Student Demographics, Research Demographics, and Disability-Specific Demographics for the National Sample of Student Researchers with Disabilities.**

| **Student demographics** | **Survey participants with disabilities n = 152 % (n)** | **Research demographics** | **Survey participants with disabilities n = 152 % (n)** | **Disability-specific demographics** | **Survey participants with disabilities n = 152 % (n)** |
|---|---|---|---|---|---|
| **Gender** | | **Duration of time in research** | | **Disability type[b]** | |
| Woman | 78.9 (120) | 6 months or less | 40.8 (62) | Mental health disability (e.g., anxiety, depression, PTSD) | 58.6 (89) |
| Man | 15.1 (23) | 1-2 years | 41.4 (63) | Hearing loss (e.g., deafness) | 2.6 (4) |
| Non-Binary/ Gender Fluid | 3.9 (6) | 2-3 years | 15.8 (24) | Learning and/or psychological disability (e.g., autism, dyslexia) | 24.3 (37) |
| Decline to state | 2.0 (3) | 4 years or more | 2.0 (3) | Chronic health condition (e.g., cancer, diabetes, multiple sclerosis) | 15.8 (24) |
| **Race/ethnicity** | | **Hours per week in research** | | Physical disability (e.g., cerebral | 5.9 (9) |

| | | | | | |
|---|---|---|---|---|---|
| | | | | palsy, spina bifida) | |
| Asian/Pacific Islander | 15.8 (24) | 1 - 5 | 21.1 (32) | Vision Loss (e.g., blind) | 1.3 (2) |
| Black/African American | 2.0 (3) | 6 – 10 | 47.4 (72) | Decline to state | 9.2 (14) |
| Hispanic/Latinx | 9.2 (14) | 11 – 15 | 14.5 (22) | | |
| White/Caucasian | 67.1 (102) | 16 hours or more | 16.4 (25) | | |
| Other | 3.9 (6) | Decline to state | 0.7 (1) | | |
| Decline to state | 2.0 (3) | **Compensation**[a] | | | |
| **Year in college** | | Course credit | 69.7 (106) | | |
| First year | 3.9 (6) | Volunteer | 38.2 (58) | | |
| Second year | 17.1 (26) | Paid | 27.6 (42) | | |
| Third year | 22.4 (34) | **Primary mentor** | | | |
| Fourth year | 44.1 (67) | Graduate student | 28.9 (44) | | |
| Fifth year or greater | 11.8 (18) | Post-doc | 8.6 (13) | | |
| Decline to state | 0.7 (1) | Staff member (e.g., lab coordinator, lab manager) | 14.5 (22) | | |
| **College generation status** | | PI (Principal Investigator)/faculty member | 44.1 (67) | | |

| | | | | | |
|---|---|---|---|---|---|
| First generation | 23.7 (36) | Other | 3.9 (6) | | |
| Continuing generation | 75.7 (115) | **Institution type** | | | |
| Decline to state | 0.7 (1) | R1 public | 53.9 (82) | | |
| **Grade Point Average (GPA)** | | R1 private | 19.7 (30) | | |
| Mean (Standard Deviation) | 3.54 (0.38) | Masters-granting institution | 14.5 (22) | | |
| Range | 2.00-4.00 | Primarily undergraduate institution | 11.8 (18) | | |
| **Age** | | | | | |
| Mean (Standard Deviation) | 21.5 (3.8) | | | | |
| Range | 18-47 | | | | |
| **Military veteran** | | | | | |
| Yes | 3.9 (6) | | | | |
| No | 92.8 (141) | | | | |
| Decline to state | 3.3 (5) | | | | |

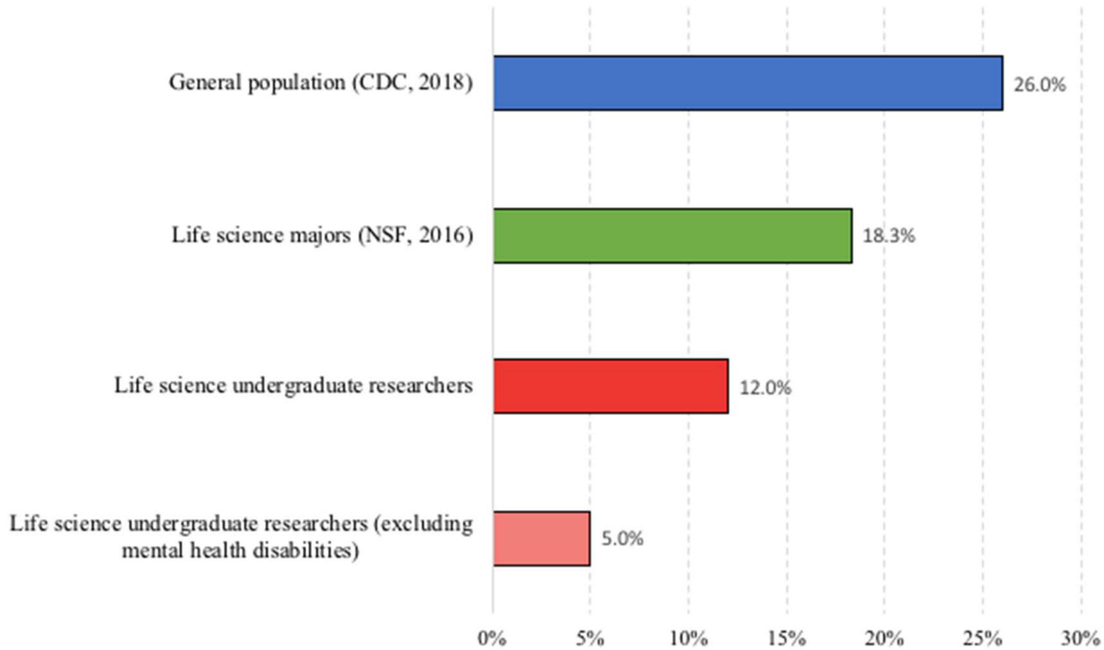
a Students had the option to report multiple forms of compensation, so percentages add up to >100%
b Students had the option to report more than one disability, so percentages add up to >100%

**Table 5-2. Summary of Interview Participant Demographics.**

| Student-Level Demographics | Interview Participants n = 20 % (n) | Research Demographics | Interview Participants n = 20 % (n) | Disability Demographics | Interview Participants n = 20 % (n) |
|---|---|---|---|---|---|
| **Gender** | | **Duration of time in research** | | **Disability type[b]** | |
| Woman | 70.0 (14) | 6 months or less | 30.0 (6) | Mental health disability (e.g., anxiety, depression, PTSD) | 55.0 (11) |
| Man | 20.0 (4) | 1-2 years | 30.0 (6) | Hearing loss (e.g., deafness) | 20.0 (4) |
| Non-Binary/ Gender Fluid | 5.0 (1) | 2-3 years | 35.0 (7) | Learning and/or psychological disability (e.g., autism, dyslexia) | 50.0 (10) |
| Decline to state | 5.0 (1) | 4 years or more | 5.0 (1) | Chronic health condition (e.g., cancer, diabetes, multiple sclerosis) | 25.0 (5) |
| **Race/Ethnicity** | | **Hours per week in research** | | Physical disability (e.g., cerebral palsy, spina bifida) | 10.0 (2) |
| Asian/Pacific Islander | 20.0 (4) | 1 - 5 | 15.0 (3) | Vision Loss (e.g., blind) | 0.0 (0) |
| Black/African American | 0.0 (0) | 6 – 10 | 40.0 (8) | **Diagnosis** | |
| Hispanic/Latinx | 15.0 (3) | 11 – 15 | 15.0 (3) | Yes | 90.0 (18) |

| | | | | | |
|---|---|---|---|---|---|
| White/Caucasian | 55.0 (11) | 16 hours or more | 30.0 (6) | No | 10.0 (2) |
| Other | 0.0 (0) | **Compensation**[a] | | **Registered at Disability Resource Center** | |
| Decline to state | 10.0 (2) | Course credit | 65.0 (13) | Yes | 65.0 (13) |
| **Year in college** | | Volunteer | 55.0 (11) | No | 35.0 (7) |
| First year | 5.0 (1) | Paid | 50.0 (10) | | |
| Second year | 15.0 (3) | **Mentor** | | | |
| Third year | 25.0 (5) | Graduate student | 25.0 (5) | | |
| Fourth year | 45.0 (9) | Post-doc | 15.0 (3) | | |
| Fifth year or greater | 5.0 (1) | Staff member (e.g., lab coordinator, lab manager) | 20.0 (4) | | |
| Decline to state | 5.0 (1) | PI (Principal Investigator)/faculty member | 30.0 (6) | | |
| **College generation status** | | Other | 10.0 (2) | | |
| First generation | 15.0 (3) | **Institution type** | | | |
| Continuing generation | 80.0 (16) | R1 public | 55.0 (11) | | |
| Decline to state | 5.0 (1) | R1 private | 20.0 (4) | | |
| **Grade Point Average (GPA)** | | Master's-granting | 15.0 (3) | | |
| Mean (Standard Deviation) | 3.37 (0.54) | Primarily undergraduate institution | 10.0 (2) | | |

| | | | | | |
|---|---|---|---|---|---|
| Range | 2.00-3.90 | | | | |
| **Age** | | | | | |
| Mean (Standard Deviation) | 21.2 (2.4) | | | | |
| Range | 18-29 | | | | |
| **Military veteran** | | | | | |
| Yes | 5.0 (1) | | | | |
| No | 90.0 (18) | | | | |
| Decline to state | 5.0 (1) | | | | |
| a Students had the option to report multiple forms of compensation, so percentages add up to >100%<br>b Students had the option to report more than one disability, so percentages add up to >100% | | | | | |




**Classification of disability used in respective data collection**

**CDC, 2018:** Mobility (serious difficulty walking or climbing stairs), cognition (serious difficulty concentrating, remembering, or making decisions), independent living (difficulty doing errands alone), hearing loss (deafness or serious hearing difficulty), vision loss (blindness or serious difficulty seeing), and self-care (difficult dressing or bathing)

**NSF, 2016:** Blindness, deafness, severe vision or hearing impairment, substantial limitation of mobility, or any other physical, mental, or emotional condition within the last six months

**Data from Study 1**: Learning disability (e.g. dyslexia), Mental health/psychological disability (e.g. anxiety, depression, PTSD), Physical disability (e.g. cerebral palsy, spina bifida, dwarfism), Chronic health condition (e.g. cancer, diabetes, multiple sclerosis), Visual loss (e.g. blind), Hearing loss (e.g. deaf), Other (please describe), None of these apply

**Figure 5-1. Representation of Individuals with Disabilities in the General Population, Life Science Majors, and Life Science Undergraduate Research.**

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# CHAPTER 6

## CONCLUSION

My dissertation provides evidence that students with disabilities are, in fact, encountering challenges as learning environments continue to evolve from traditional, in-person, lecture learning spaces toward more interactive, technical, and authentic learning experiences. In Chapter 2, I documented the types of challenges that students with disabilities may experience in active learning science courses from the perspective of Disability Resource Center directors as well as the difficulties with the overall process of providing accommodations for students with disabilities in active learning. In Chapter 3, I discovered the ways in which online learning environments can present challenges with the ways in which students with disabilities are accommodated in their online science courses and discuss issues that students reported they experienced due to the rapid transition to online learning as a result of the COVID-19 pandemic. Moreover, in Chapter 4, I followed up on this work to assess the extent to which students were adequately accommodated in their online science courses one year following the transition to online learning and found that students largely reported not being properly accommodated even after colleges and universities had time to prepare for new accommodations given the changing learning environment. Finally, Chapter 5 I report that students with disabilities are underrepresented in the high-impact practice of undergraduate research and documented the unique challenges, solutions, contributions, and benefits undergraduate researchers with disabilities experience.

Overall, my dissertation addresses a substantial gap in the literature by beginning to identify the problems, challenges, and issues with accommodating students with disabilities as learning environments evolve. This exploratory work provides a much needed foundation for future research that can empirically test the effectiveness of the recommendations that emerged from this research. Ultimately, a goal of this dissertation is that it can lead to changes in practice and policy that can make evolving learning spaces more inclusive of students with disabilities. For example, DRC staff can use these results to begin to develop interventions and accommodations for students with disabilities in novel learning environments. A feature of many evolving environments, including online education and active learning courses, is a greater emphasis on technology and particularly outside coursework on online learning platforms. Should there be a common set of accommodations that are expected for videos, for frequent low-stakes assessments online, or for group communication online? Instructors can think about ways to design their courses from a universal design standpoint so that students may need fewer accommodations (Burgstahler & Moore, 2009; Rose & Meyer, 2002). Instructors can also predict what aspects of their courses may cause challenges for students with disabilities and choose to modify those aspects of their courses for all students. I also advocate for more communication between instructors and DRCs as well as between institutions to share effective ways in which students can be accommodated in a particular learning context. However, more research needs to be done to identify the most effective and appropriate ways to deliver high-quality and evidence-based accommodations to students with disabilities in undergraduate science education.

Overall, this work has contributed to our knowledge and understanding of theory and models of disability. While much of the previous literature on individuals with disabilities exclusively focuses on either the social or medical model of disability (Brisenden, 1986; Shakespeare, 2006), my dissertation shows that either of these, in their extremes, does not sufficiently describe the experience of a student with a disability. This dissertation has taken a pragmatic approach to characterize the experiences of students with disabilities by considering both the practical limitations that students with disabilities may have while also considering the biases, attitudes, and stigmas that society holds around including individuals with disabilities. Moreover, to my knowledge, this is the first of its kind to posit that individuals with disabilities are an underrepresented group of individuals that can contribute community cultural wealth to a given learning environment, namely undergraduate research experiences. It is my hope that this approach can inform future research, policy, and interventions by considering the holistic experience of a student with a disability in a given science learning environment.

One limitation of my dissertation is that it was only able to consider the experience of certain stakeholders, particularly the perspectives from DRC staff and students in isolation (**Figure 6-1**). Additional research should consider the perspectives of all stakeholders and consider triangulating these data for each learning environment. For example, Chapter 2 could benefit from including the instructors who teach active learning science courses and document their experiences working with both students with disabilities and DRC staff to accommodate the students in their courses. Similarly, Chapter 5 could benefit from the perspectives of DRC staff for ideas for how they would accommodate a student with a disability in a high-impact practice, such as undergraduate research. It is my hope that the education research community can build upon this work to better understand the holistic process of providing adequate accommodations for students with disabilities and so that students with disabilities are better supported. Finally, even though my work focused on students in science, it would be of interest to see how these findings compare to students in social sciences or humanities.

For this dissertation, I focused on three specific evolving learning environments in this dissertation: active learning science courses, online science courses, and undergraduate research experiences. However, additional work should explore the challenges and opportunities for students with disabilities in other non-traditional, evolving learning environments, such as study abroad programs, lab-based and field-based courses, virtual reality learning spaces, and more. Innovation in education will persist and that means that any standard suite of accommodations is likely not to be sufficient indefinitely. Thus, we must continue to collect data and evaluate the experiences of students with disabilities to ensure that their educational experiences are maximized. Additionally, I recommend that universities prioritize staffing and training to support faculty members, instructors, and DRC professionals who work with students with disabilities to equip them with the knowledge and skills necessary to ensure that they are fully accommodated in any innovative learning environment.

Finally, undergraduate learning environments are only going to continue to change and evolve moving forward. Just as Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 did not envision what a college learning environment would look like in 2021 (Americans with Disabilities Act of 1990, 1990; Section 504 of the Rehabilitation Act, 1973), it is difficult to say what undergraduate science education will look like in the next 30-50 years. However, instead of retroactively responding to these inevitable changes to learning environments, this work suggests that we should be proactively considering changes to our learning spaces and how students with disabilities will be able to experience, navigate, and be included in undergraduate science education in the future.

## Tables and Figures

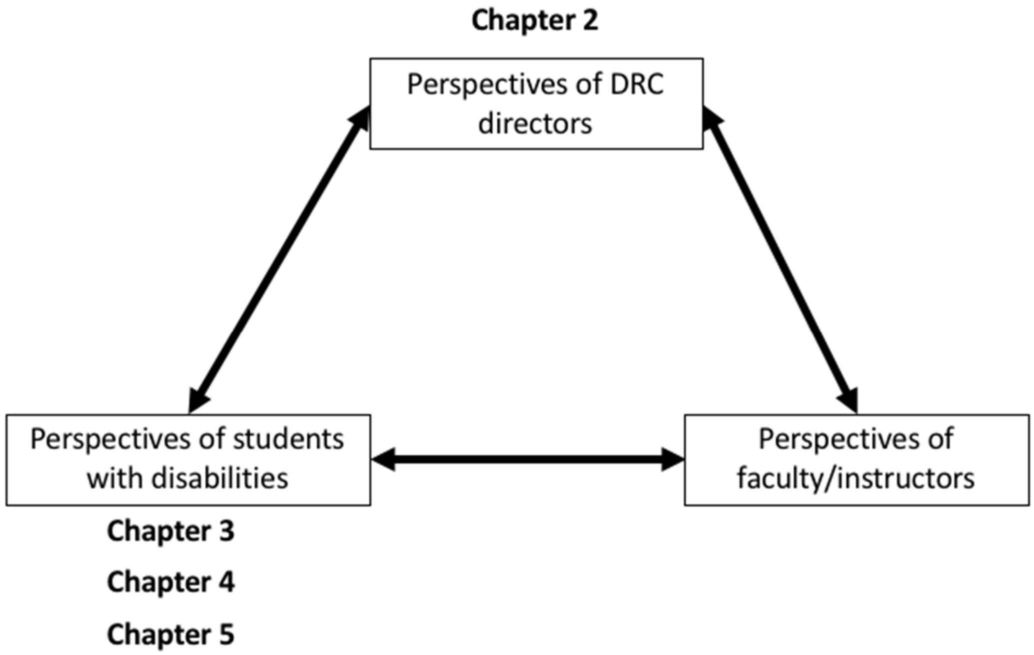


**Figure 6-1. Stakeholders Involved in Accommodating Students with Disabilities and the Corresponding Chapters that Incorporate the Perspectives of Each Stakeholder.**

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# APPENDIX

## APPENDIX A. CHAPTER 2 SUPPLEMENTAL MATERIAL

APPENDIX A-1. Copy of Interview Questions Analyzed

Awareness:

1. Are you familiar with the term active learning? For the purposes of the interview, could you please describe your definition of active learning? (If they are unfamiliar, define active learning to them as students engaging in the learning process through clicker questions, small group work/discussion, and cold/random call)
2. To what extent are the large-enrollment science courses at your institution being taught using active learning?
    a. How do you know these large-enrollment science courses are being taught in an active learning way? (e.g. conversations with faculty/students, data on enrollment sizes, number of accommodations for certain courses, etc.)

Procedures:

1. Can you walk me through the standard process for receiving accommodations at your institution?
    a. What documentation is required in order for students to receive accommodations?
        i. What happens if a student cannot provide such documentation?
    b. Do instructors have say in what accommodations they should get?
        i. What if an instructor suggests a different accommodation?
2. If a student is enrolled in a large-enrollment science course that is taught in an active learning way, what is the process for them to receive appropriate accommodations for that course?
3. What accommodations are provided for large-enrollment active learning science courses?
    a. To what extent are these accommodations similar or different to what is typically offered to students in traditional lectures?
4. Are students notified that the course will be taught in an active learning way? (e.g. by the instructors, by your office)
    a. If no: Is it up to the student to identify if the course they are enrolled in is being taught in an active learning way?
5. How are accommodations for large-enrollment active learning science courses determined?
    a. To what extent do you work with active learning instructors to identify accommodations?
    b. To what extent do you work with the students to identify accommodations?

6. Are students required to identify their own accommodations for the active learning courses they are enrolled in?
7. To what extent do you work with students on self-advocacy skills for assisting them in seeking appropriate accommodations?
8. If an instructor teaches in an active learning way, can they notify your office in order to set up appropriate accommodations for students?

Challenges:

1. What, if any, unique challenges have you found when working with students with disabilities enrolled in large-enrollment active learning science classes?
2. Have you noticed students with particular disabilities struggling with small group work?
    a. Yes: What types of disabilities? How, if at all, have you been able to accommodate these students?
3. Have you noticed students with particular disabilities struggling with clicker questions?
    a. Yes: What types of disabilities? How, if at all, have you been able to accommodate these students?
4. Have you noticed students with particular disabilities struggling with cold call or random call?
    a. Yes: What types of disabilities? How, if at all, have you been able to accommodate these students?
5. Have you noticed students with particular disabilities struggling with required attendance/participation?
    a. Yes: What types of disabilities? How, if at all, have you been able to accommodate these students?
6. Have you noticed students with particular disabilities struggling with active learning technologies (e.g. videos, online learning platforms, etc.)?
    a. Yes: What types of disabilities? How, if at all, have you been able to accommodate these students?
7. Have you noticed students with particular disabilities struggling with any other types of active learning?
    a. Yes: What types of disabilities? How, if at all, have you been able to accommodate these students?

Alternatives:

1. What, if any, alternatives are there for students enrolled in an active learning science course if accommodations cannot be implemented?

Recommendations:

1. What recommendations would you have for improving the ways in which you can accommodate students with disabilities in active learning courses?

APPENDIX A-2.

Table 1: Institutional characteristics of Disability Resource Centers interviewed

| Interview # | Public or Private? | Carnegie Classification | Region |
|---|---|---|---|
| 1 | Public | R2 | Midwest |
| 2 | Public | R1 | South |
| 3 | Public | R1 | Midwest |
| 4 | Public | R2 | Midwest |
| 5 | Private | Master’s | West |
| 6 | Public | R1 | West |
| 7 | Public | R1 | South |
| 8 | Public | R2 | South |
| 9 | Public | R2 | West |
| 10 | Public | R2 | Midwest |
| 11 | Public | R1 | West |
| 12 | Public | R2 | West |
| 13 | Public | R1 | West |
| 14 | Public | R1 | Midwest |
| 15 | Public | R2 | Midwest |
| 16 | Public | R1 | South |
| 17 | Public | R2 | Midwest |
| 18 | Public | R2 | Northeast |
| 19 | Public | R1 | West |
| 20 | Public | Baccalaureate | South |
| 21 | Public | Master’s | Midwest |

| | | | |
|---|---|---|---|
| 22 | Public | R1 | Northeast |
| 23 | Public | R1 | South |
| 24 | Public | Master’s | Northeast |
| 25 | Public | R2 | Midwest |
| 26 | Public | R1 | West |
| 27 | Public | R2 | Midwest |
| 28 | Public | R1 | South |
| 29 | Private | R1 | Midwest |
| 30 | Public | R2 | Midwest |
| 31 | Public | Master’s | West |
| 32 | Public | R1 | Northeast |
| 33 | Private | R1 | Northeast |
| 34 | Public | R2 | Midwest |
| 35 | Public | R1 | Midwest |
| 36 | Public | Master’s | West |
| 37 | Public | Master’s | Northeast |

All institutions were classified as large-enrollment (>10,000 students) based on the Carnegie Classification of Institutions of Higher Education.

R1: Doctoral Universities – Very high research activity: includes only institutions that awarded at least 20 research/scholarship doctoral degrees and had at least $5 million in total research expenditures, in addition to high indexes for aggregate level of research activity and per-capita research activity.
R2: Doctoral Universities – High research activity: includes only institutions that awarded at least 20 research/scholarship doctoral degrees and had at least $5 million in total research expenditures.
Master’s Colleges and Universities – includes institutions that

awarded at least 50 master's degrees and fewer than 20 doctoral degrees.
Baccalaureate Colleges – includes institutions where baccalaureate or higher degrees represent at least 50 percent of all degrees, but fewer than 50 master's degrees or 20 doctoral degrees were awarded.

APPENDIX A-3. Example survey question for disability status

Have you currently, or previously, been impacted by one or more of the following conditions? (Check all that apply):

- Learning disability (e.g. autism, dyslexia)
- Mental health and psychological disability (e.g. anxiety, depression, bipolar disorder)
- Physical disability (e.g. cerebral palsy, spina bifida)
- Chronic health conditions (e.g. cancer, diabetes)
- Vision loss (e.g. blind)
- Hearing loss (e.g. deaf)
- Other (please describe)
- None of these apply

Do you feel as though you may need support or assistance in arranging accommodations for this course with the Disability Resource Center (DRC)?

- Yes (please describe)
- No
- I am not sure

The following question can be given only to students who indicate having a disability, but could also be given to all students in your class:

Given that this course uses active learning (e.g. group work, clicker questions), it may require a different approach than some of your other courses. However, we would like to know how we can make the course more inclusive for all students.

What, if anything, can we do to make you as successful as possible in this course?

APPENDIX A-4. Copy of final coding rubrics and number of directors who reported each theme

| Theme | Description of theme | n (%) (n = 37) |
|---|---|---|
| Active learning processes/procedures | | |
| Familiar with active learning | Director states that they are familiar with the term "active learning." This could include directors providing a definition of active learning or providing examples of common active learning pedagogy (e.g. cold call, small group work/discussion, etc.). | 37 (100%) |
| Provides standard suite of active learning accommodations | Director states that their department has a suite of accommodations that are implemented specifically for students who are enrolled in an active learning course. | 0 (0%) |
| Has provided proactive accommodations for active learning | Director states any instance where their DRC has provided a single proactive accommodation at any point. Examples of such proactive accommodations include notifying a student that they are in an active learning course, discussions specifically about AL practices/challenges at the beginning of the semester/initial meetings, and if an instructor reaches out to the DRC to discuss their AL pedagogy/practice. | 6 (16%) |
| Systematic process in place for proactive accommodations | Director states evidence that their DRC has been able to proactively accommodate every student enrolled in an active learning science course. Examples of this could include having a list of all identified active learning courses, a suite of accommodations specifically for active learning courses, or mentions that they know of each active learning science course at their institution. | 0 (0%) |
| Provides individualized accommodations for active learning | Director states an example when they specifically accommodated students with a certain type of the disability. Examples of such individualized accommodations include instructors pre-determining groups for students struggling with small group work, ensuring that mobile app/clicker was accessible for users, and creating a flexible attendance and participation agreement form. | 37 (100%) |
| Challenges associated with active learning | | |
| Small group work | | |
| Learning disability- | Director states examples of students with specific learning disabilities (such as ADHD, students on the | 30 (81%) |

| | | |
|---|---|---|
| difficulty working with others | autism spectrum, dyslexia, etc.) having difficulty engaging/working with students in small group work. | |
| Mental health- difficulty working with others | Director states example(s) of students with mental health and psychological disabilities (such as social anxiety or depression) having difficulty when working with other students in small group work. | 21 (57%) |
| Physical disability- classroom layout is not conducive to group work | Director states example(s) of students with physical disabilities (such as students utilizing a wheelchair or crutches) having difficulty participating based on classroom layout (e.g. stairs or limited space between rows of desks). | 4 (11%) |
| Physical disability- difficulty writing quickly on assignments | Director states example(s) of students with physical disabilities having difficulty with fine motor dexterity impacting their ability to write notes and finish class assignments. | 1 (3%) |
| Hearing loss- difficulties hearing discussion | Directors states example(s) of students with a partial or significant hearing loss having difficulty engaging with a small group because it was difficult to hear the discussion. | 5 (14%) |
| Hearing loss- off-site transcriptionists have difficulty listening and transcribing group's conversation | Director states example(s) of students with partial or significant hearing loss having difficulty with off-site transcriptionists not able to listen and transcribe small group discussions accurately. | 2 (5%) |
| Clicker questions | | |
| Learning disability- students are not provided enough time to process | Director states example(s) of students with specific learning disabilities (such as ADHD, students on the autism spectrum, dyslexia, etc.) having difficulty with not being provided enough time to process clicker questions. | 12 (32%) |
| Physical disability- fine motor difficulties clicking buttons | Director states example(s) of students with physical disabilities having trouble clicking buttons on the clicker due to their problem with fine motor dexterity. | 12 (32%) |
| Vision loss- Students cannot see questions posted | Director states example(s) of students with partial or significant vision loss having difficulty visualizing the clicker questions posted during class. | 19 (51%) |

| | | |
|---|---|---|
| Vision loss- students cannot see correct buttons on clicker | Director states example(s) of students with partial or significant vision loss having difficulty visualizing the buttons on the clicker and accurately answering the question. | 17 (46%) |
| Cold/random call | | |
| Learning disability- students are not provided enough time to process | Director states example(s) of students with specific learning disabilities (such as ADHD, students on the autism spectrum, dyslexia, etc.) having difficulty being randomly requested to answer questions with a short amount of time to process and answer the question. | 12 (32%) |
| Learning disability- students have difficulty speaking in front of the class | Director states example(s) of students with specific learning disabilities (such as ADHD, students on the autism spectrum, dyslexia, etc). having difficulty with speaking in front of the class. | 12 (32%) |
| Mental health- students do not feel comfortable sharing ideas with the class | Director states example(s) of students with mental health and phycological disabilities (such as social anxiety or depression) having difficulty with comfort sharing ideas and answering questions during lecture. | 19 (51%) |
| Required participation | | |
| Physical disability- students may miss multiple class periods | Director states example(s) of students with a physical disability (such as muscular dystrophy, cerebral palsy, etc.) that prevented them from attending the course regularly. | 6 (16%) |
| Chronic illness- students may miss multiple class periods | Director states example(s) of students with a chronic illness (such as diabetes, Chron’s Disease, chronic migraines, asthma, etc.) that prevented them from attending the course regularly. | 25 (68%) |
| Mental health- students may miss multiple class periods | Director states example(s) of students with a mental health and psychological disability (such as episodic depression or anxiety) that prevented them from attending the course regularly. | 23 (62%) |
| Online activities (online homework, videos) | | |
| Vision loss- online learning platforms not accessible | Director states example(s) of students with partial or significant vision loss having difficulty accessing online learning platforms with their assistive technologies. | 16 (43%) |
| Hearing loss- difficulty hearing videos and activities | Director states example(s) of students with partial or significant hearing loss having difficulty hearing videos and online activities within the course. | 2 (5%) |

| | | |
|---|---|---|
| Hearing loss-instructor videos are not always captioned | Director states example(s) of students with a partial or significant hearing loss having difficulty engaging with the videos and online activities since they are not closed-captioned. | 4 (11%) |
| Accommodations for active learning challenges | | |
| Small group work | | |
| Students choose their groups | Director states example(s) of providing accommodations for students struggling with small group work with allowing students to pre-determine their groups. | 3 (8%) |
| Instructor pre-determines groups | Director states example(s) of providing accommodations for students struggling with small group work with the instructor pre-determining the students' groups. | 4 (11%) |
| Reducing the size of groups | Director states example(s) of providing accommodations for students struggling with a small group by reducing the size of the groups (e.g. working in pairs). | 5 (14%) |
| Students can interact virtually | Director states example(s) of providing accommodations for students struggling with small group work by allowing them to interact virtually via Zoom or Skype. | 3 (8%) |
| Real-time captioner or scribe placed within groups | Director states example(s) of providing accommodations for students struggling with small group work by providing real-time captioners or scribes for students with hearing loss or vision loss. | 2 (5%) |
| Changing the physical setting where groups work | Director states example(s) of providing accommodations for students struggling with small group work by changing the physical setting where groups can work. An example of this is that the small groups can work in the hallway or outside instead of working in the classroom. | 1 (3%) |
| Providing accessible tables, chairs, and furniture conducive to group work | Director states example(s) of providing accommodations for students struggling with small group work by providing accessible furniture for students in their classrooms. An example of this is when a student in a wheelchair needs a table that can be adjusted in height. | 2 (5%) |
| Completing an alternative assignment for credit | Director states example(s) of providing accommodations for students struggling with small group work by instructors providing an alternate assignment that does not require a small group to complete it. | 13 (35%) |
| Clicker questions | | |
| Access to clicker questions before class | Director states example(s) of providing accommodations for students struggling with the processing and answering of clicker questions by providing access to the questions before the start of class. | 8 (22%) |

| | | |
|---|---|---|
| Student motions to the instructor when they have read the question | Director states example(s) of providing accommodations for students who may struggling with the processing and answering of clicker questions by the students creating a hand signal notifying the instructor that they have had time to process the questions. | 1 (3%) |
| Instructors reads the questions aloud before starting time | Director states example(s) of providing accommodations for students struggling with the processing and answering of clicker questions by having instructors to read the question aloud before starting the timer. This gives students optimal time for processing the questions. | 4 (11%) |
| Clicker question can be completed before/after class | Director states example(s) of providing accommodations for students struggling with the processing and answering of clicker questions by allowing students to answer the questions before/after class before being graded. This gives students optimal time for processing the questions. | 2 (5%) |
| Increased amount of time given to answer clicker questions | Director states example(s) of providing accommodations for students struggling with the processing and answering of clicker questions by the giving students an increased amount of time to answer a clicker question. This gives students optimal time for processing the questions. | 5 (14%) |
| A volunteer can physically aid the student in clicking in their answer | Director states example(s) of providing accommodations for students struggling with the usage of clickers by having a volunteer help the student click in their desired answers. | 4 (11%) |
| Ensure that the mobile app/clicker is accessible to users | Director states example(s) of providing accommodations for students struggling with the usage of clickers by ensuring the mobile app/clicker is accessible. An example of this is when a student’s vision loss requires a clicker that has braille on the buttons. | 6 (16%) |
| Cold/random call | | |
| Instructor signals/notifies the student they will be called on soon (advanced notice) | Director states example(s) of providing accommodations for students struggling with the processing and answering of questions from the professor by the professor signaling to that student that they will be called on soon to answer a question. | 9 (24%) |
| Students are only called on when the student’s hand is raised (opt-out of random call) | Director states example(s) of providing accommodations for students struggling with the processing and answering of questions from the professor by the student being able to answer the question voluntarily. | 3 (8%) |

| | | |
|---|---|---|
| Instructor does not call on the student to speak, or they can pass | Director states example(s) of providing accommodations for students struggling with the processing and answering of questions from the professor by the student being able to pass on the question asked by the professor. | 7 (19%) |
| Student submits answer through a written form | Director states example(s) of providing accommodations for students struggling with the processing and answering of questions from the professor by the student being able to answer the question through submission of the answer being written or typed. | 2 (5%) |
| Required participation | | |
| Flexible attendance and participation agreement form | Director states example(s) of providing accommodations for students struggling with the required participation/attendance by creating a flexible attendance and participation agreement form that is approved by the DRC, instructor, and student. | 33 (89%) |
| Students can attend class virtually (e.g. Skype, Zoom) | Director states example(s) of providing accommodations for students struggling with the required participation/attendance by allowing students to virtually attend class via Zoom or Skype. | 2 (5%) |
| Online activities (e.g. online homework, videos) | | |
| Ensure all videos are captioned (or replaced with one that is) | Director states example(s) of providing accommodations for students struggling with online activities by ensuring all videos that are utilized within the course are captioned. | 6 (16%) |
| Allow students to work with an assistant to read/input answers | Director states example(s) of providing accommodations for students struggling with online activities by allowing students to work with an assistant to read/input answers for the student's classwork. | 3 (8%) |
| Notify 3rd party software companies of inaccessible products | Director states example(s) of providing accommodations for students struggling with online activities by allowing DRCs and instructors to notify 3rd party software companies that their product is inaccessible to students with certain types of disabilities. | 6 (16%) |
| Add tactile graphics, braille, or 3D models to online instruction | Director states example(s) of providing accommodations for students struggling with online activities by adding tactile graphics, braille, or 3D models to online instruction. | 2 (5%) |
| Use screen readers to make online platforms accessible | Director states example(s) of providing accommodations for students struggling with online activities by making online platforms accessible for screen readers. | 5 (14%) |

# APPENDIX B. CHAPTER 3 SUPPLEMENTAL MATERIAL

APPENDIX B-1. Outreach email to DRCs

Dear Disability Resource Center,

I hope this email finds you well. We are a team of biology education researchers at [insert institution] interested in improving the experiences of college students with disabilities in undergraduate science education. We are specifically interested in the challenges and opportunities students with disabilities may have faced associated with the transition to online coursework as a result of COVID-19.

We are writing to ask if you would be willing to forward the following message (e.g. emailing list, listserv, etc.) to your students who are registered with your office at your university as we would like to conduct interviews with students to learn more about their experiences. Any information would remain confidential and communicated anonymously; our goal is to collect information from students nationally so that we can learn from each other to better serve our students. We would be happy to share back with you what we learn.

Thank you in advance for your time and consideration.

APPENDIX B-2. Outreach email to students

Hello Students,

We are a team of biology education researchers at [insert institution] interested in improving the experiences of college students with disabilities in undergraduate science education. We are specifically interested in the challenges and opportunities students with disabilities may have faced associated with the transition to online coursework as a result of COVID-19.

If you have a disability and were enrolled in STEM courses in spring 2020, we would be interested in how the rapid transition to online education as a result of COVID-19 has impacted your STEM courses in a 30 – 60 minute online interview.

After completing the interview, you will complete a brief demographic survey. In exchange for your time, we will provide you with a $15 gift card to Amazon. Participation in the research is voluntary, and you must be 18 years or older to participate.

If you would be willing to share your insights, please fill out this poll with the most convenient time for you: [link to sign up]

We are planning to conduct all interviews over Zoom for your convenience. If you have any questions, please contact [PI, PI email].

We believe that it is very important to learn more about the experiences of students with disabilities in order to create a more inclusive biology community!

Thank you for considering!

APPENDIX B-3. Interview script

Background:

1) Before COVID-19 (spring 2020 term), were you enrolled in any in-person STEM courses? [If not: end interview]
    a) Could you briefly describe the courses you are in?

2) Could you briefly describe your disability and how it impacts you on a daily basis?

3) Are you currently registered for services through your university's Disability Resource Center?
    a) Could you briefly describe your accommodations that you commonly use in your STEM courses?

4) How, if at all, has COVID-19 affected your disability in the context of your STEM courses?

Online STEM questions:

5) Given the transition to online instruction with the circumstances surrounding COVID-19: What do you think are some of the challenges online STEM courses present for you as a student with a disability?

6) Were your accommodations impacted or modified by the transition to online?
    a) If yes: Who initiated these additional modifications? You? Instructor? DRC?
        i) Please describe the process of how you received additional modifications.
        ii) How helpful was the modification for you?

7) Did you use additional accommodations for your disability in your online STEM courses?
    a) If yes: Who initiated these additional accommodations? You? Instructor? DRC?
        i) Please describe the process of how you received additional accommodations.
        ii) How helpful were these additional accommodations for you?

8) Do you think you would have benefitted from receiving any additional accommodations? If so, which ones?
    a) If yes: Did anything prevent you from getting additional accommodations?

9) What accommodations have not been helpful in your online STEM courses?

10) How could your accommodations be improved in any way for online?

11) To what extent did you have to advocate for yourself as a student with a disability during the transition to online STEM courses? Please explain.

12) Did you feel like your institution broadly supported students with disabilities during the transition to online instruction?
    a) To what extent did you feel instructors considered students with disabilities in transitioning their instruction to online?

13) Did you feel that your institution did anything that was not supportive of students with disabilities during the transition to online instruction?

14) To what extent did you feel the transition to online impacted your overall performance in your STEM courses?
    a) Did you spend more or less time on your courses after the transition to online?

15) What might you suggest to improve your experience as a student with a disability in online STEM courses?

16) Is there anything else that you would like to add?

APPENDIX B-4. Copy of post-interview survey questions

Thank you for taking the time to interview. We really appreciate it!

We would like you to take a quick (less than 5 minute) survey to tell us more about your experience with your disability in online courses and give us information so we can get you your online gift card. There are no right or wrong answers. Your answers will never be shared with anyone outside of the research team.

At the end of the survey, you will be asked for the email address you would like your Amazon gift card sent to. We will be emailing you the gift card as soon as possible!

1. Have you currently, or previously, been impacted by one or more of the following conditions? Please check all that apply.
   - Learning disability (e.g. dyslexia)
   - Mental health/psychological disability (e.g. anxiety, depression, PTSD)
   - Physical disability (e.g. cerebral palsy, spina bifida, dwarfism)
   - Chronic health condition (e.g. cancer, diabetes, multiple sclerosis)
   - Visual loss (e.g. blind)
   - Hearing loss (e.g. deaf)
   - Other (please describe)
   - None of these apply

2. Please write the name of your disability or diagnosed medical condition.

3. In 2-3 sentences, please describe how your disability or diagnosed medical condition affects you on a daily basis.

4. Have you been formally diagnosed for your disability or medical condition from a physician/psychiatrist/medical professional? If you selected multiple, please list each.
   - Yes (Please list the year you were diagnosed)
   - No

5. Are you currently (or have you previously been) registered with your university's Disability Resource Center (or equivalent office)?
   - Yes
   - No

6. Which institution did you attend in spring 2020? (e.g. Arizona State University, Carleton College)

7. How many science, technology, engineering, and math (STEM) courses were you enrolled in during spring 2020?

8. Did you receive any accommodations prior to the transition to online education

9. Did you receive any accommodations after the transition to online education?

APPENDIX B-5. Copy of post-interview demographic questions

1. I most closely identify as

- Man
- Woman
- Other
- Decline to state

2. I most closely identify as

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic, Latinx, or Spanish origin
- Pacific Islander
- White/Caucasian
- Other (please describe)
- Decline to state

3. I most closely identify as a

- First-generation college student whose parents' highest level of education is a high school diploma or less
- Non-first generation college student (at least one parent has some college)
- Non-first generation college student (at least one parent has finished college)
- Decline to state

4. Do you serve as a primary caregiver for someone other than yourself? (e.g. children, sick parent)

- Yes
- No
- Decline to state

5. What is your parent's highest completed level of education? If you have more than one parent with differing levels of education, choose the higher of the two.

- Less than high school completed
- High school diploma or GED
- Some college but no degree

- Associate degree (for example: AA, AS)
- Bachelor's degree (for example: BA, AB, BS)
- Master's degree (for example: MA, MS, MEng, MEd, MSW, MBA)
- Higher than a Master's degree (for example: PhD, MD, JD)
- Other (please describe)
- Decline to state

6. What is your best guess for the yearly income of the household in which you grew up?

- Low income (less than $25,000)
- Middle-low income ($25,000-$49,999)
- Middle income ($50,000-$99,999)
- Middle-high income ($100,000 to $199,999)
- High income ($200,000 or higher)
- Decline to state

7. Please indicate your native language (the language you spoke at home when you were growing up).

- English
- Spanish
- Other (please describe)
- Decline to state

8. Please indicate the average total time (round trip) that you spent commuting to campus per day (prior to COVID-19).

- I lived on campus/did not commute
- Less than 30 minutes
- 30 - 59 minutes
- 60 minutes or more (please specify)
- Decline to state

9. Please indicate the average number of hours you worked a job per week during the spring 2020 semester (prior to COVID-19).

- I did not work

- 1 - 10 hours
- 11 - 20 hours
- 21 - 30 hours
- 31 - 40 hours
- 40 hours or more
- Decline to state

10. Please indicate the option that most closely reflects your college experience.
    - I transferred to my institution from a 2-year college, a community or junior college, or a technical college
    - I transferred to my institution from another 4-year institution
    - I started my college career at my institution
    - I attend a 2-year college, a community or junior college, or a technical college
    - If none of the above reflect your experience, please describe your experience below.
    - Decline to state

11. How long have you attended college while pursuing your undergraduate degree?
    - 1 year or less (first-year student)
    - 2 years (sophomore)
    - 3 years (junior)
    - 4 years (senior)
    - 5 years or more
    - I have graduated with my undergraduate degree
    - Other (please describe)

12. What is your grade point average (GPA)?

13. Do you identify as a member of the LGBTQIA* community?

*lesbian, gay, bisexual, queer/questioning, intersex, asexual/aromantic
- Yes
- No
- Decline to state

14. Please select the word or words that best describe your identity.

- Lesbian
- Gay
- Bisexual
- Queer
- Transgender
- Intersex
- Asexual
- Other, please describe
- Decline to state

15. How old are you?

16. I most closely identify with
    - Currently or having previously struggled with anxiety or an anxiety disorder
    - Having never struggled with an anxiety disorder
    - Decline to state

17. I most closely identify with
    - Currently or having previously struggled with depression or a depression disorder
    - Having never struggled with depression
    - Decline to state

18. What is your ultimate career goal?
    - Medical doctor (e.g., pediatrician, surgeon, etc.)
    - Scientific researcher (e.g., research professor, biologist, etc.)
    - Other health professional (e.g., physician assistant, physical therapist, nurse, etc.)
    - Other science career (e.g., zookeeper, lab manager, etc.)
    - Other, please describe
    - I do not know what I want to do yet

APPENDIX B-6.

Table 1. Additional interview participant demographics

| Demographics | All students<br>n = 66<br>% (n) |
|---|---|
| Hours worked per week | |
| Do not work | 48% (32) |
| 1-10 hours | 17% (11) |
| 11-20 hours | 17% (11) |
| 21-30 hours | 9% (6) |
| 31-40 hours | 2% (1) |
| 40+ hours | 5% (3) |
| Decline to state | 3% (2) |
| Serves as primary caregiver (e.g., to a child) | |
| Yes | 8% (5) |
| No | 86% (57) |
| Decline to state | 6% (4) |
| Career goal | |
| Medical doctor | 15% (10) |
| Other health professionals | 15% (10) |
| Other science careers | 12% (8) |
| Scientific researcher | 20% (13) |
| Other | 24% (16) |
| Undecided | 11% (7) |
| Decline to state | 3% (2) |
| Parent's education level | |
| Less than high school completed | 2% (1) |
| High school diploma or GED | 24% (16) |
| Some college but no degree | 9% (6) |
| Associate Degree | 2% (1) |
| Bachelor's Degree | 18% (12) |
| Master's Degree | 23% (15) |
| Doctoral Degree | 15% (10) |
| Decline to state | 8% (5) |
| Household income level | |
| Low income | 8% (5) |
| Middle-low income | 30% (20) |
| Middle income | 33% (22) |
| Middle-high income | 12% (8) |
| High income | 6% (4) |
| Decline to state | 11% (7) |
| Member of the LGBTQIA Community | |
| No | 44% (29) |
| Yes | 42% (28) |
| Decline to state | 14% (9) |

APPENDIX B-7.

Table 2. List of students' pseudonyms with their self-reported disability types

| Interview | Pseudonym | Chronic health condition (e.g. cancer, diabetes, multiple sclerosis) | Hearing loss (e.g. deaf) | Learning disability (e.g. dyslexia) | Mental health/psychological disability (e.g. anxiety, depression) | Physical disability (e.g. cerebral palsy, spina bifida) | Vision loss (e.g. blind) | Total # |
|---|---|---|---|---|---|---|---|---|
| 1 | Michael | x | | x | x | x | | 4 |
| 2 | Zhang | x | | | x | | | 2 |
| 3 | Luna | | | x | x | | | 2 |
| 4 | Pedro | | | x | | | | 1 |
| 5 | Destiny | x | | x | x | | | 3 |
| 6 | Desiree | x | | | x | | | 2 |
| 7 | Eva | x | | | | | | 1 |
| 8 | Marty | x | | | | x | | 2 |
| 9 | Sean | x | | | | | | 1 |
| 10 | Scarlet | | | x | x | | | 2 |
| 11 | Molly | | | x | x | | | 2 |
| 12 | Oscar | x | | x | | | | 2 |
| 13 | Alexis | | | | x | | | 1 |
| 14 | Diane | x | | x | x | | | 3 |
| 15 | Danielle | | | | x | | | 1 |
| 16 | Naomi | | | x | x | | | 2 |
| 17 | Timothy | | | x | | | | 1 |
| 18 | Selena | | | x | | | | 1 |
| 19 | Angelica | | | x | x | | | 2 |
| 20 | Austin | | | x | | | | 1 |
| 21 | Renea | | | | x | | | 1 |
| 22 | Juliet | | | x | | | | 1 |
| 23 | Bryan | | | x | | | | 1 |
| 24 | Javier | | | x | x | | | 2 |
| 25 | Ilene | | | x | x | | | 2 |
| 26 | Peter | | | x | | | | 1 |
| 27 | Sylvia | x | | | x | x | | 3 |
| 28 | Jessica | x | | x | x | | | 3 |
| 29 | Phillip | x | | | | | x | 2 |
| 30 | Crystal | x | | | | x | | 2 |
| 31 | Summer | x | | | x | | | 2 |
| 32 | Terry | x | x | x | x | x | | 5 |
| 33 | Bertha | | x | | | | | 1 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 34 | Ashley | | | x | | | | 1 |
| 35 | Bella | x | | x | x | x | | 4 |
| 36 | Charlie | | | x | x | | | 2 |
| 37 | Alex | | | | x | | | 1 |
| 38 | Carlos | | | | x | | | 1 |
| 39 | Linda | x | | x | | | | 2 |
| 40 | Sherry | x | | x | x | | x | 4 |
| 41 | Joe | | | x | x | | | 2 |
| 42 | Ryan | | | | x | x | | 2 |
| 43 | Lizzie | | | | x | | | 1 |
| 44 | Michelle | x | | | | | | 1 |
| 45 | Franklyn | | | x | x | | | 2 |
| 46 | Alexandria | | | | x | | | 1 |
| 47 | Natalia | | | x | x | | | 2 |
| 48 | Rena | | | x | x | | | 2 |
| 49 | Kate | x | | | x | x | | 3 |
| 50 | Laura | | | x | | | | 1 |
| 51 | Rose | | | x | | | | 1 |
| 52 | Arielle | | | | x | | | 1 |
| 53 | Nyeli | | | x | | | | 1 |
| 54 | Ellen | x | | | x | | | 2 |
| 55 | Tom | | | | x | | | 1 |
| 56 | Arthur | | | x | x | | | 2 |
| 57 | Melissa | | | | | x | | 1 |
| 58 | Ethan | | | | x | x | | 2 |
| 59 | Henry | | x | x | | | | 2 |
| 60 | Savanah | x | | | x | | | 2 |
| 61 | Lydia | | | | x | | | 1 |
| 62 | Sal | | | x | | | | 1 |
| 63 | Katherine | | x | | x | | | 2 |
| 64 | Marne | | | | x | | | 1 |
| 65 | Tanya | | | | x | | | 1 |
| 66 | Levi | | | x | x | | | 2 |
| | Total | 22 | 4 | 36 | 43 | 10 | 2 | 117 |

APPENDIX B-8.

Table 3. List of disabilities reported by students

| Type of Disability | Total number of disabilities reported n = 148 |
|---|---|
| Chronic health condition (e.g. cancer, diabetes, multiple sclerosis) | 36 |
| Chronic pain | 3 |
| Ehlers-Danlos Syndrome | 3 |
| Chronic daily migraines | 2 |
| Postural Orthostatic Tachycardia Syndrome (POTS) | 2 |
| Seizures | 2 |
| Chronic sinusitis | 2 |
| Brain injury | 1 |
| Chronic active autoimmune disease | 1 |
| Chronic fatigue syndrome | 1 |
| Crohn’s disease | 1 |
| Diabetes | 1 |
| Diaphragmatic hernia | 1 |
| Eating disorder | 1 |
| Epilepsy | 1 |
| Fibromyalgia | 1 |
| Gastroparesis | 1 |
| Gastroesophageal reflux disease (GERD) | 1 |
| Hip dysplasia | 1 |
| Insomnia | 1 |
| Narcolepsy | 1 |
| Osteoarthritis | 1 |
| Post-concussive syndrome | 1 |
| Polysplenia heterotaxy syndrome | 1 |
| Rheumatoid arthritis | 1 |
| Tetralogy of Fallot | 1 |
| Tremors | 1 |
| Trigeminal neura1ia | 1 |
| Working memory deficit | 1 |
| Hearing loss (e.g. deaf) | 6 |
| Hearing impairment | 4 |
| Auditory deficit | 1 |

| | |
|---|---|
| Auditory processing disorder | 1 |
| Learning disability (e.g. autism, dyslexia) | 13 |
| Dyslexia | 5 |
| Autism | 4 |
| Dyscalculia | 2 |
| Dysgraphia | 1 |
| Non-verbal learning disorder | 1 |
| Mental health/psychological disability (e.g. anxiety, depression, PTSD) | 79 |
| Attention-deficit/hyperactivity disorder (ADHD)/ Attention-deficit disorder (ADD) | 25 |
| Anxiety | 22 |
| Depression | 14 |
| Post-traumatic stress disorder (PTSD) | 9 |
| Bipolar | 5 |
| Asperger syndrome | 1 |
| Obsessive-compulsive disorder (OCD) | 1 |
| Panic disorder | 1 |
| Unspecified dissociative disorder | 1 |
| Physical disability (e.g. cerebral palsy, spina bifida, dwarfism) | 12 |
| Fibromyalgia | 2 |
| Interstitial Cystitis | 1 |
| Inflammatory bowel disease | 1 |
| Chronic pain | 1 |
| Complex regional pain syndrome | 1 |
| Epilepsy | 1 |
| Generalized joint hypermobility | 1 |
| Head trauma | 1 |
| Hip dysplasia | 1 |
| Nerve damage | 1 |
| Parkinson’s disease | 1 |
| Visual impairment (e.g. blind) | 2 |
| Retina damage | 1 |
| Retina disparity | 1 |

APPENDIX B-9.

Table 4. Percent of students in the final dataset by institution type and geographic location

| Institution | n = 66<br>% (n) | Enrollment size |
|---|---|---|
| R1 Public University in the Southwest | 20% (13) | 53,000 |
| R1 Private University in the Northeast | 8% (5) | 14,000 |
| R2 Public University in the Southwest | 15% (12) | 29,000 |
| R2 Public University in the Midwest | 7% (4) | 20,000 |
| R2 Public University in the Northwest | 21% (14) | 27,000 |
| M1 Public University in the Southwest | 5% (3) | 13,000 |
| M1 Public University in the Northwest | 23% (15) | 16,000 |

APPENDIX B-10. Coding rubric with code descriptions

| Reported issues with specific accommodations or resources no longer being available following the transition to online instruction | |
|---|---|
| Theme | Description |
| Lack of reduced-distraction testing environment | Student describes that they no longer had access to their reduced-distraction environment testing from home. A student may be distracted from their surroundings at home during testing. This could also include instructors that opted to use Zoom video/audio to administer exams, which student may mention is distracting by seeing/hearing other students during exam. If a student describes that sharing their screen leads to stress/anxiety, it would be coded here. |
| Extended testing time was not properly administered | Student describes that there were issues with the way they were supposed to receive extended testing time. This could be that the instructor forgot to add it to the system, there was not a way to add it to the system, or that they had to specifically ask for it to be added after taking an exam without the extended time. |
| Lack of access to note-taking accommodations | Student describes that they were no longer able to access their note-taking as an accommodation although they would have found this helpful. Student could describe an issue with being able to communicate with the student who used to give them their notes, the DRC no longer facilitating this process, or some other reason that they are no longer able to access their notes from their course due to the change in format. |
| Lack of (reduced) access to campus/tutoring resources | Student describes that they had no access or reduced access to campus tutoring resources. Student could mention that the university/college did not offer tutoring online after the transition, the online tutoring was difficult to navigate, or they were unsure how to access tutoring resources after the transition to online. This could also include resources such as the library, computer labs, etc. |
| Unique challenges with online instruction that may have been lessened with an accommodation | |
| Issues with test proctoring technology | Student describes that there were issues with the systems that instructors chose to proctor their exams online. A student could describe that the proctoring system would flag them for cheating if they took a break (as one of their accommodations) during an exam. This could also be any issues with the proctoring system leading to an increase in anxiety for the student. Note: This is an issue with the testing system itself and not with the instructor administering it. This could be increased anxiety due to the way in which exams are proctored. |
| Reduced access to material or information | Student describes that there is little real-time feedback or ways for the student to get help when they may be struggling with a particular task or assignment. Student often describes that they have difficulties getting questions answered, contacting the instructor/TA, or that there is a delay in them receiving what they need to complete an assignment/task. This could also be access to an instructor after class or in office hours. |
| Video delivery of information is not always accessible | Student describes that videos are not always in a format that is accessible to them. This could include students who describe videos as not being closed-captioned or transcribed. It could also include students discussing that watching videos results in strain, fatigue, stress, etc. A student may also mention that their existing technologies (e.g. screen readers) are incompatible with video formatting and it makes it difficult to access. |
| Barriers to receiving accommodations effectively and efficiently after the transition to online instruction | |

| | |
|---|---|
| Instructors did not consider students with disabilities | Student describes that the instructor did not consider students with disabilities as they transitioned online. They could have forgotten that they received a particular accommodation. A student may say that the instructor was busy with transitioning their course to online and forgot about students with disabilities. For example, an instructor may have not put in extended time for the students in their course that take their exams at the DRC and receive extended time. In general, this could come in the form of students with disabilities not being considered in the transition to online. |
| Instructors made assumptions about appropriateness of accommodations | Student describes that the instructor made assumptions about what was or was not appropriate for them following the transition online. Some students may describe the instructors' rationale for this being that students have an increased time to work on assignments, they gave extended time to all students, or that their specific accommodation was no longer necessary in an online learning environment. Students need to specifically mention that they no longer were able to access or use their accommodations because the instructor did not recognize them. If an instructor no longer allows a student to use or access their accommodation, it would be coded here. |
| Lack of information from DRC/university about adapting/specific accommodations for online | Student describes that they felt as though there was not a plan in place about how their accommodations might change as a result of the transition to online. They did not feel as though the DRC/instructors knew what to do in terms of changing existing accommodations to better suit them in an online environment. This could be when students describe that changes were happening so quickly that the university was unable to address concerns or send out information to students about how their accommodations would be impacted or modified by the transition to online. |
| Student was required to self-advocate for accommodation/ modifications | Student describes that they had to self-advocate for what they needed. This could be in the form of emails/phone calls to the DRC. It could also be communicating with the instructor to work on modifying their accommodations or ensuring that they had what they needed to be successful after the transition to online (that they would not have to do in-person; and more than what an average student would have to do). If a student mentions advocating for their needs/disability more broadly/generally, it would be coded here (unless they mention disclosing more information). |

# APPENDIX C. CHAPTER 4 SUPPLEMENTAL MATERIAL

APPENDIX C-1. Outreach email sent to students

Hello students!

We are biology education researchers from [University] looking to conduct a study on students' experiences in online college science courses! We are interested in hearing what you think about online college science courses. Your thoughts and opinions will help us improve the way science is taught at [University] and across the U.S.!

If you have been enrolled in at least one ONLINE college science course and would like to help us out by providing us with your opinion, we ask that you would participate in this study by taking a 15-minute survey about your thoughts in exchange for extra credit in the course(s) you were recruited from; you may receive extra credit in multiple courses from which you were recruited. If you do not wish to participate in this survey, there will be an alternative extra credit option available in your class. If you are in multiple courses that will be offering extra credit through this study, we would like you to provide all of your instructors' names so we can make sure your extra credit is accounted for in all the classes.

You will provide your name in the survey so that we can tell your instructor you completed the survey and they can give you extra credit. However, your instructor will never see your name associated with your other responses to the survey. This survey will be completely voluntary and confidential. Your survey responses will not affect your grades at all. Your instructors will never see your answers to this survey. Please do not use instructor names or that of others when responding to the open-ended questions.

You may skip any question if you do not wish to answer it. Your participation in this study is voluntary. You must be 18 years or older to participate in the study.

APPENDIX C-2. Copy of survey questions analyzed

1. Have you currently, or previously, been impacted by one or more of the following conditions? (Check all that apply):
    - Learning disability (e.g., dyslexia)
    - Mental health and/or psychological disability (e.g., anxiety, depression, bipolar disorder)
    - Physical disability (e.g., cerebral palsy, spina bifida)
    - Chronic health condition (e.g., cancer, diabetes)
    - Vision loss (e.g., blind)
    - Hearing loss (e.g., deaf)
    - Other (please describe)
    - None of these apply
    -
2. Are you currently registered for services through [University] Disability Resource Center (DRC) for Spring 2021?
    - Yes
    - No
    - Unsure

3. Has the online format of Spring 2021 online science courses led to any new challenges for your disability?
    - Yes
    - No
    - Prefer not to say
    -
4. Have you actually received any new or adapted accommodations from the DRC for your Spring 2021 online science courses?
    - Yes
        - [If yes] Please describe the new or adapted accommodations that you have received during Spring 2021?
    - No
    -
5. Given your disability, to what extent do you feel like you are currently being properly accommodated in your online college science courses?
    - Properly accommodated (all my needs are met)
    - Somewhat accommodated (some of my needs are met)
    - Not accommodated (none of my needs are met)
    -

6. [If properly accommodated or somewhat accommodated was selected] Please tell us about any accommodations that you are receiving in the online science learning environment that are helpful to you.
    -
7. [If somewhat accommodated or not accommodated was selected] Please select any of the following that apply:
    - I have had trouble accessing note-taking accommodations that I used to access during in-person science courses
    - I have had trouble accessing a quiet, distraction-free testing environment
    - I have not had access to longer times to take exams
    - Video proctoring software (e.g., RPNow) creates additional issues for my disability
    - The extra time spent on the computer creates additional issues for my disability
    - I have had issues accessing video lectures or other instructional materials given my disability (e.g., videos not closed-captioned)
    - Instructors have forgotten about my accommodations
    - Instructors have not recognized my need for accommodations given the online learning environment
    - My accommodation is not possible to be delivered online
    - Other, please describe
    -
8. Please tell us about any ideas you have for accommodations in the online science learning environment that you are not receiving that could be helpful to you.
    -
9. I most closely identify as
    - Woman
    - Man
    - Non-binary
    - Other, please describe
    - Prefer not to say
    -
10. I most closely identify as
    - American Indian or Alaska Native
    - Asian
    - Black or African American
    - Hispanic, Latinx, or Spanish origin
    - Pacific Islander
    - White/Caucasian

- Other, please describe
- Prefer not to say
- 

11. What is your parent or guardian's highest level of education? If you have more than one parent or guardian with differing levels of education, choose the higher of the two.
    - Less than high school completed
    - High school diploma or GED
    - Some college but no degree
    - Associate degree (e.g., AA, AS)
    - Bachelor's degree (e.g., BA, AB, BS)
    - Master's degree (e.g., MA, MS, MEng, MEd, MSW, MBA)
    - Higher than a master's degree (e.g., PhD, MD, JD)
    - Prefer not to say
    - 
12. How long have you attended college while pursuing your undergraduate degree?
    - 1 year or less
    - 2 years
    - 3 years
    - 4 years
    - 5 years or more
    - I have graduated with my undergraduate degree
    - Prefer not to say

APPENDIX C-3. Coding rubrics with code descriptions

Table 1. New accommodations reported by students

| Code | Description |
|---|---|
| Additional extended testing time | An amount of time added to the current amount of time allotted on an exam allowed for the rest of the class. |
| Flexible assignment deadlines | Students are allowed extended assignment deadlines. |
| Recorded lectures and class meetings | Instructor records, either via video or audio recording, the class lecture and shares lecture recording with students. |
| Flexible class attendance | Student’s disability may occasionally impact the student’s ability to attend class, so flexible attendance allows the student disability-related absences. |
| Online note-taking services | Accommodation that provides students with the provision of materials in advance to facilitate the note-taking process, or by soliciting all the students who are registered in the course to find another student to take notes and share them with the student with a disability. |
| No exam lockdown browsers/cameras | Online proctored software not required for exam. |
| Closed-captioning of videos/lectures | Online lectures are captioned in real-time by displaying the text of the speaker. |
| Option for cameras off during class | Students are not required to keep cameras on during the class period. |
| Reduced distraction home environment (e.g., earplugs) | Providing students with a space intended to minimize the distractions associated with testing. |
| Instructors share slides prior to class | Instructor shares presentation slides before the class period. |
| Work in smaller (breakout) groups | Students will work with one or two of their peers in a small breakout group. |

| | |
|---|---|
| Use of clear masks by instructor | Clear masks safely make the instructors' mouths visible to students with disabilities. |

Table 2. Accommodations reported by students that could have been helpful

| Code | Description |
|---|---|
| Flexible assignment deadlines | Students are allowed extended assignment deadlines. |
| Additional extended testing time | An amount of time added to the current amount of time allotted on an exam allowed for the rest of the class. |
| More frequent communication from instructors about expectations and due dates | Additional communication and announcements from instructors to remind students of assignment due dates and overall expectations for assignments. |
| No exam lockdown browsers/cameras | Online proctored software not required for exam. |
| Closed-captioning of videos and lectures | Online lectures are captioned in real-time by displaying the text of the speaker. |
| Eliminating all timed assignments | Removing all timed assignments, assessments, and exams |
| Open-book exams | Allowing students to have access to their books or notes during exam periods |
| Flexible class attendance | Student’s disability may occasionally impact the student’s ability to attend class, so flexible attendance allows the student disability-related absences. |
| Online note-taking services | Accommodation that provides students with the provision of materials in advance to facilitate the note-taking process, or by soliciting all the students who are registered in the course to find |

| | |
|---|---|
| | another student to take notes and share them with the student with a disability. |
| Recorded lectures and class meetings | Instructor records, either via video or audio recording, the class lecture and shares lecture recording with students. |
| Work in smaller breakout groups | Students will work with one or two of their peers in a small breakout group. |
| Option for cameras off during class | Students are not required to keep cameras on during the class period. |
| Reduced distraction home environment (e.g., earplugs) | Providing students with a space intended to minimize the distractions associated with testing. |
| Instructors share slides prior to class | Instructor shares presentation slides before the class period. |
| Socially distant testing centers on campus | Students could complete their exams from an on-campus, COVID safe, socially distant testing site to ensure a distraction-free exam environment. |
| Requests for printed materials | Providing students with printed materials (or facilitating with helping them with printer resources). |

# APPENDIX D. CHAPTER 5 SUPPLEMENTAL MATERIAL

## APPENDIX D-1. Copy of survey questions analyzed (Study I)

Research demographics

1. Have you, currently or in the past, participated in a scientific undergraduate research experience while enrolled in college? For example, conducting research with a faculty member or in a faculty member's lab.
   - o Yes
   - o No [Students are directed to the end of the survey]

2. Have you only participated in a summer research experience (e.g., REU) that you did not participate in during the school year?
   - o Yes [Students are directed to the end of the survey]
   - o No

3. Please choose the response that most closely reflects how long you participated in your first undergraduate research experience.
   - o 6 months or less
   - o 1-2 years
   - o 2-3 years
   - o 4 years or more

4. On average, how many hours per week do/did you spend working on undergraduate research (inside and outside the lab)?
   - o 1-5 hours
   - o 6-10 hours
   - o 11-15 hours
   - o 16 hours or more
   - o Decline to state

5. Please choose the response that most accurately describes how you are/were compensated for your time working on undergraduate research. (Check all that apply):
   - o I receive/received course credit for my time participating in undergraduate research
   - o I receive/received money for my time participating in undergraduate research (e.g., wage, stipend)
   - o I volunteer/volunteered my time in undergraduate research (do not/did not receive credit or money)

6. Please indicate who you work/worked with most closely during your first undergraduate research experience.

- PI (Principal Investigator)/faculty member
- A graduate student
- A post-doc
- A staff member (e.g., lab coordinator, lab manager)
- Other, please describe

7. Please type in the name of the institution you are attending
(e.g., Arizona State University, University of Colorado, Boulder)

Student demographics

8. I most closely identify as

- Woman
- Man
- Non-binary/Gender fluid
- Other (please describe)
- Decline to state

9. I most closely identify as

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic, Latinx, or Spanish Origin
- Pacific Islander
- White/Caucasian
- Other (please describe)
- Decline to state

10. How long have you attended college while pursuing your undergraduate degree?

- 1 year or less (first-year student)
- 2 years (sophomore)
- 3 years (junior)
- 4 years (senior)
- 5 years or more
- Decline to state

11. I most closely identify as

- First-generation college student whose parents' highest level of education is a high school diploma or less
- First-generation college student (at least one parent has some college)
- Non-first generation college student (at least one parent has finished college)
- Decline to state

12. What is your grade point average (GPA)?

13. How old are you?

14. I most closely identify as a(n)
    - Military veteran
    - Active duty service member
    - Military reserve
    - None of the above
    - Decline to state

Disability-specific demographics

15. Have you currently, or previously, been impacted by one or more of the following conditions? (Check all that apply):
    - Learning disability (e.g., autism, dyslexia)
    - Mental health and psychological disability (e.g., anxiety, depression, bipolar disorder)
    - Physical disability (e.g., cerebral palsy, spina bifida)
    - Chronic health conditions (e.g., cancer, diabetes)
    - Vision loss (e.g., blind)
    - Hearing loss (e.g., deaf)
    - Other (please describe)
    - None of these apply

Interview recruitment

16. We are interested in hearing more about your thoughts about undergraduate research. Are you interested in being contacted about participating in an online follow-up interview (via Skype, FaceTime, Zoom, etc.) in exchange for a $15 gift card?
    - Yes (please enter your email)
    - No

APPENDIX D-2. Outreach email to students for interviews (Study II)

Hi XXXXXX,

We are a team of biology education researchers working to improve student experiences in undergraduate biology. We are specifically interested in the experiences of students with disabilities in undergraduate research.

To our knowledge, there have been no studies exploring the experiences of students with disabilities in undergraduate research. We believe that it is very important to learn more about the experiences of students with disabilities in order to create a more inclusive biology community.

If you identify as having a disability, we would be interested in hearing about your experience in undergraduate research in a 30 – 60 minute online interview. In exchange for your time, we will provide you with a $15 gift card to Amazon.

If you would be willing to share your insights, please fill out this poll with the most convenient time for you: [insert link]

Please only sign up for a single time slot. Times listed may be different from your time zone.

We are planning to conduct all interviews over Zoom for your convenience. If another platform or medium is more appropriate or accessible for you, please let me know as I am more than happy to accommodate.

Thank you for considering!

APPENDIX D-3. Copy of interview questions analyzed (Study II)

Thank you for agreeing to talk with me. My name is XXXXX, and I am a biology education researcher, and I study ways to improve the experiences of undergraduate science students. To our knowledge, nobody has actually explored the experiences of undergraduate science students with disabilities in research, so our goal is really just to learn more about you and your experience. As someone who identifies as having a disability, I am particularly interested in your unique experiences. There are no right or wrong answers to any of these questions. If you do not feel comfortable answering a question, just let me know. Given that COVID-19 has likely impacted your research experience, please try to reflect on your experience prior.

Background

The goal of this study is to interview students with disabilities about their experience in undergraduate research, so could you please begin by describing your disability (or disabilities)? What are the symptoms of your disability (or disabilities) and how does it impact you on a daily basis?

Diagnosis and DRC

Have you been formally diagnosed for your disability (or disabilities) from a physician/psychiatrist/medical professional?

Are you currently registered for services through your university's Disability Resource Center?

- If yes: Could you briefly describe what your accommodations look like?
- If not: Why not?

Involvement in undergraduate research

Can you briefly describe your undergraduate research experience or experiences?

Why did you want to do undergraduate research?

To what extent did your disability inform the type of research that you sought to participate in?

- How, if at all, has your disability (or disabilities) affected what you choose to study in research?

Did you have any fear that your disability (or disabilities) would affect your experience in research?

Benefits and challenges of undergraduate research
To what extent has your disability (or disabilities) affected your research in a negative way?

To what extent has your disability (or disabilities) affected your research in a positive way?
- o Do you feel as though your disability (or disabilities) gives you any advantages in research?
- o What benefits or contributions, if any, do you believe you bring to undergraduate research given your disability (or disabilities)?

What, if anything, about undergraduate research has negatively affected your view of your disability (or disabilities)?

What, if anything, about undergraduate research has positively affected your view of your disability (or disabilities)?

Please describe any barriers you think undergraduate research presents for you as a researcher with a disability (or disabilities).

What, if anything, about undergraduate research can exacerbate your disability (or disabilities)?

Revealing/concealing disability
Who in your lab knows about your disability (or disabilities)?
- o Grad mentor(s)
- o PI/faculty mentor(s)
- o Other people who aren't mentors

How did they find out?
- o If not: Why not?

If they know: To what extent do you feel as though people's expectations for you changed when they found out about your disability (or disabilities)?

If they do not know: To what extent do you feel people's expectations would change for you if they found out about your disability (or disabilities)?

Accommodations and solutions in research
To what extent have you sought formal accommodations for your disability (or disabilities) in research (e.g., from the Disability Resource Center or department)?

To what extent have you sought informal accommodations for your disability (or disabilities) in research (e.g., conversations with mentors)?

To what extent is the process similar or different to the process you have gone through to receive accommodations in your lab courses?

To what extent are your accommodations in research similar or different to your accommodations in your courses?

Did you participate in undergraduate research for course credit?

- If you enrolled for credit: Are you aware that you may be eligible for accommodations for research through the DRC since it is a course?

What additional accommodations do you think could have been helpful given your disability (or disabilities)?

To what extent do you feel as though you have to personally advocate for what you need to be successful as an individual with a disability (or disabilities) in undergraduate research?

Career
What is your career goal?

How important is doing undergraduate research to your future career?

How, if at all, has your disability (or disabilities) impacted your career decisions?

Recommendations for improving the experiences of undergrads with disability
Tell me about a way that you think research mentors can positively affect students with disabilities in their research labs.

Is there anything else you would like to share?

Thank you so much for your time. Right after this, I am going to send you a quick follow-up email that asks you questions about your disability. There will be no right or wrong answers. At the end of the survey, we will ask for your email you would like your gift card sent to, and we will send that to you next week.

APPENDIX D-4. Copy of post-interview survey questions analyzed (Study II)

Research demographics

1. Please choose the response that most closely reflects how long you participated in your first undergraduate research experience.
   - 6 months or less
   - 1-2 years
   - 2-3 years
   - 4 years or more

2. On average, how many hours per week do/did you spend working on undergraduate research (inside and outside the lab)?
   - 1-5 hours
   - 6-10 hours
   - 11-15 hours
   - 16 hours or more
   - Decline to state

3. Please choose the response that most accurately describes how you are/were compensated for your time working on undergraduate research. (Check all that apply):
   - I receive/received course credit for my time participating in undergraduate research
   - I receive/received money for my time participating in undergraduate research (e.g., wage, stipend)
   - I volunteer/volunteered my time in undergraduate research (do not/did not receive credit or money)

4. Please indicate who you work/worked with most closely during your first undergraduate research experience.
   - PI (Principal Investigator)/faculty member
   - A graduate student
   - A post-doc
   - A staff member (e.g., lab coordinator, lab manager)
   - Other, please describe

5. Please type in the name of the institution you are attending (e.g., Arizona State University, University of Colorado, Boulder)

Student demographics

6. I most closely identify as

- Woman
- Man
- Non-binary/Gender fluid
- Other (please describe)
- Decline to state

7. I most closely identify as
   - American Indian or Alaska Native
   - Asian
   - Black or African American
   - Hispanic, Latinx, or Spanish Origin
   - Pacific Islander
   - White/Caucasian
   - Other (please describe)
   - Decline to state

8. How long have you attended college while pursuing your undergraduate degree?
   - 1 year or less (first-year student)
   - 2 years (sophomore)
   - 3 years (junior)
   - 4 years (senior)
   - 5 years or more
   - Decline to state

9. I most closely identify as
   - First-generation college student whose parents' highest level of education is a high school diploma or less
   - First-generation college student (at least one parent has some college)
   - Non-first generation college student (at least one parent has finished college)
   - Decline to state

10. What is your grade point average (GPA)?

11. How old are you?

12. I most closely identify as a(n)
    - Military veteran
    - Active duty service member
    - Military reserve
    - None of the above

- Decline to state

Disability-specific demographics

13. Have you currently, or previously, been impacted by one or more of the following conditions? (Check all that apply):
    - Learning disability (e.g., autism, dyslexia)
    - Mental health and psychological disability (e.g., anxiety, depression, bipolar disorder)
    - Physical disability (e.g., cerebral palsy, spina bifida)
    - Chronic health conditions (e.g., cancer, diabetes)
    - Vision loss (e.g., blind)
    - Hearing loss (e.g., deaf)
    - Other (please describe)
    - None of these apply

14. Have you been formally diagnosed for your disability or medical condition from a physician/psychiatrist/medical professional?
    - Yes
    - No

15. Are you currently (or have you previously been) registered with your university's Disability Resource Center (or equivalent office)?
    - Yes
    - No

Gift card information

16. Please type the email address where you would like to receive your $15 Amazon gift card.

APPENDIX D-5.

Table 1. List of students' pseudonyms with their self-reported disability types (Study II).

| Interview | Pseudonym | Chronic health condition (e.g., cancer, diabetes, multiple sclerosis) | Hearing loss (e.g., deaf) | Learning disability (e.g., dyslexia) | Mental health/psychological disability (e.g., anxiety, depression) | Physical disability (e.g., cerebral palsy, spina bifida) | Visual loss (e.g., blind) | Total # |
|---|---|---|---|---|---|---|---|---|
| 1 | Amy | X | | | X | | | 2 |
| 2 | Skylar | | | X | | | | 1 |
| 3 | Anita | | | X | X | | | 2 |
| 4 | Naomi | | | | | X | | 1 |
| 5 | Michele | X | | | X | | | 2 |
| 6 | Wanda | | | X | X | | | 2 |
| 7 | Jesse | X | | X | | | | 2 |
| 8 | Odette | | | X | X | | | 2 |
| 9 | Hugh | X | X | X | X | X | | 5 |
| 10 | Gabriella | | X | | | | | 1 |
| 11 | Rebecca | | | X | | | | 1 |
| 12 | Temple | | | X | | | | 1 |
| 13 | Judith | | | | X | | | 1 |
| 14 | Karin | | | | X | | | 1 |
| 15 | Albert | | | X | | | | 1 |
| 16 | Michael | | | | X | | | 1 |
| 17 | Tia | | X | | X | | | 2 |
| 18 | Cornelius | X | | X | X | | | 3 |
| 19 | Caroline | | | X | | | | 1 |
| 20 | Katie | | X | | | | | 1 |
| | Total | 5 | 4 | 10 | 11 | 2 | 0 | 33 |

APPENDIX D-6.

Table 2. Coding rubric with code descriptions (Study II).

| Unique challenges experienced by students with disabilities in undergraduate research | | |
|---|---|---|
| Theme | Description | % (n) |
| Difficulties carrying out research tasks | Students describe that they may have difficulties carrying out specific tasks in their research experience as a result of their disability (e.g., difficulties carrying, reaching, etc. or spending long periods of time working on specific tasks). This is specific to the type of research task that the student is doing and not the general type of research (which would be coded elsewhere). Students could describe a "flare up" or symptoms related to their disability that prevent them from fully carrying out research tasks. Students could describe that these difficulties ultimately lead to challenges with productivity in research. | 55% (11) |
| Requires self-advocacy in URE | Students describe that they are required to self-advocate (more than what they typically would) in order to receive what they need to be successful in their URE. Students could also discuss having difficulties with advocating in the context of UREs. | 45% (9) |
| Challenges getting help in research | Students describe that it can be difficult to reach out to their mentor regarding getting help, accommodations, or solutions in their research experience. This could be compounded by the fact that their mentor may or may not know whether they have a disability. This could also include if a student reached out to the DRC and was unable to be helped. | 40% (8) |
| Not able to live authentically in research | Students describe challenges with revealing their disability as an identity to others in their research group. This can also include students who have invisible disabilities downplaying the effect of their disability or symptoms of their disability on their performance in research. Students may also describe that there are few role models of other students/researchers with disabilities for them to look up to. | 25% (5) |
| Unique solutions experienced by students with disabilities in undergraduate research | | |
| Able to get help in research from mentor | Students describe that they are able to reach out to their mentor regarding getting help, accommodations, or solutions in their research experience. This could be having conversations with their mentor about how their disability may impact them and their research. This could also be working 1:1 with the mentor to find individualized/informal accommodations to better their overall | 45% (9) |

| | | |
|---|---|---|
| | experience in research. This often requires that the student be open to discussing and/or revealing their disability (invisible) to their mentor. | |
| Individualized solution | Student describes that they created a solution to a challenge that they were having in undergraduate research. Students can say that they created their own solution or that it was something that they came up with to lessen the effect of the challenges they were experiencing. | 40% (8) |
| Able to live authentically in research | Students describe that they are able to reveal/discuss their disability as an identity to others in their research group. This can also include students who have authentically spoken about their disability and how it may impact them. Students can share this information with other people in the lab (positive). Students may also describe that they have role models and other students/researchers with disabilities for them to look up to (either in their research labs or in science more broadly). | 25% (5) |
| Able to get help in research from DRC | Students describe that they have been able to reach out to the DRC in terms of which accommodations may work in their research experience. The student may describe that they have used their similar accommodations for their courses in their research experiences. | 15% (3) |
| Unique benefits experienced by students with disabilities in undergraduate research | | |
| Builds resilience | Student describes that undergraduate research teaches students with disabilities resiliency and may require them to overcome obstacles, which is helpful for students (in the face of adversity). This could be accomplishing and solving scientific problems which show them that they can overcome such an obstacle. Students may also go on to describe how this could parallel with some of the obstacles/adversity they face in their everyday lives as an individual with a disability. | 45% (9) |
| Builds positively to science identity | Students describe that being able to conduct undergraduate research contributes to their overall feelings of being a "scientist." This could mean that they feel like they are a part of the scientific community as a result of participating in research. Students could describe themselves as a "scientist," someone "doing science," etc. which would go beyond just confidence in their ability to do science. | 35% (7) |

| | | |
|---|---|---|
| Influences career | Students describe that their disability may inform the type of research that they ultimately want to pursue (e.g., student with neurological disability working in neurology; autism research for students with autism). | 30% (6) |
| Builds confidence or efficacy for doing science | Student describes that conducting undergraduate research can make students with disabilities "feel capable" in terms of being able to conduct scientific research. This could also be students feeling like they are able to contribute to science/can do science as an individual with a disability. | 20% (4) |
| Unique contributions of students with disabilities to undergraduate research | | |
| Sense of empathy | Students describe that they bring compassion, empathy, understanding, etc. which can inform the role that students with disabilities play in the research process. This can be students generally describing that their experience as someone with a disability can help them relate to others, relate to the research project, relate to how data is collected, etc. | 30% (6) |
| Unique perspective of students with disabilities | Students describe that as an individual with a disability, they bring a unique perspective to the research process. This could be related to how they think about research problems based on their own disability. It could also include bringing in their lived experiences of someone who has a disability. This could also include students bringing in the perspective of someone with a particular type of disability doing research on a similar type of disability (e.g., autism research with a student with autism). | 25% (5) |
| Disability provides advantage/skill set for certain tasks | Students describe that some aspect/symptom/result of their disability allows for some advantage in the research process. For example, this could include students being able to hyper-focus on certain research tasks, attention-to-detail as a result of often making mistakes due to disability, etc. This could also be students developing skills/skill sets from living with a particular disability that provides an advantage for approaching situations in the context of research (e.g., physical disability considering accessibility of field work). | 20% (4) |

APPENDIX E. PERMISSIONS FROM CO-AUTHORS

Chapter 2 of this document was previously published in CBE: Life Sciences Education with co-authors Sara Brownell, Katelyn Cooper, and Frank Guerrero who have granted permission to include the manuscript in my dissertation. Chapter 3 of this document was previously published in CBE: Life Sciences Education with co-authors Sara Brownell, Katelyn Cooper, and Frank Guerrero who have granted permission to include the manuscript in my dissertation. Chapter 4 of this document is currently under review at Journal of Microbiology and Biology Education with co-authors Sara Brownell, Katelyn Cooper, Kristen Parish, and Danielle Pais who have granted permission to include the manuscript in my dissertation. Lastly, Chapter 5 is currently under review at CBE: Life Sciences Education with co-authors Sara Brownell, Katelyn Cooper, and Danielle Pais, all of whom granted permission to include this manuscript in my dissertation.

# APPENDIX F. IRB APPROVALS FOR CHAPTER 2, 3, 4, AND 5

IRB approval for Chapter 2:

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Sara Brownell
Life Sciences, School of (SOLS)
-
Sara.Brownell@asu.edu

Dear Sara Brownell:

On 12/5/2017 the ASU IRB reviewed the following protocol:

| | |
|---|---|
| Type of Review: | Initial Study |
| Title: | Exploring the role of Disability Resource Centers (DRCs) in accommodating active learning teaching practices |
| Investigator: | Sara Brownell |
| IRB ID: | STUDY00007435 |
| Funding: | None |
| Grant Title: | None |
| Grant ID: | None |
| Documents Reviewed: | • Director Recruitment Script, Category: Recruitment Materials;<br>• 2017.12.05_DRC-Project_Consent-Form.pdf, Category: Consent Form;<br>• Director Interview Questions, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);<br>• 2017.12.05_DRC-Project_IRB.docx, Category: IRB Protocol;<br>• Logan Gin CITI Training Completion Report, Category: Non-ASU human subjects training (if taken within last 3 years to grandfather in); |

IRB approval for Chapter 3:

EXEMPTION GRANTED

Sara Brownell
CLAS-NS: Life Sciences, School of (SOLS)
-
Sara.Brownell@asu.edu

Dear Sara Brownell:

On 5/6/2020 the ASU IRB reviewed the following protocol:

| | |
|---|---|
| Type of Review: | Initial Study |
| Title: | Exploring accommodations in science and science courses for students with disabilities |
| Investigator: | Sara Brownell |
| IRB ID: | STUDY00011930 |
| Funding: | Name: SOLS: Undergraduate Programs |
| Grant Title: | |
| Grant ID: | |
| Documents Reviewed: | • 20.5.4_Interview Questions.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);<br>• 20.5.4_Post interview survey.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);<br>• 20.5.5_Interview Consent Statement.pdf, Category: Consent Form;<br>• 20.5.5_Student Accommodations Interview Recruitment Script.pdf, Category: Recruitment Materials;<br>• 20.5.5_Student Accommodations_IRB.docx, Category: IRB Protocol;<br>• 2017.03.25_CITI-Completion-Report_Gin-Logan.pdf, Category: Non-ASU human subjects training (if taken within last 3 years to grandfather in); |

IRB approval for Chapter 4:

ASU Knowledge Enterprise Development

APPROVAL: EXPEDITED REVIEW

Sara Brownell
CLAS-NS: Life Sciences, School of (SOLS)
-
Sara.Brownell@asu.edu

Dear Sara Brownell:

On 3/10/2021 the ASU IRB reviewed the following protocol:

| | |
|---|---|
| Type of Review: | Initial Study |
| Title: | Exploring student anxiety and depression in online college science courses |
| Investigator: | Sara Brownell |
| IRB ID: | STUDY00013434 |
| Category of review: | |
| Funding: | None |
| Grant Title: | None |
| Grant ID: | None |
| Documents Reviewed: | • 2.10.21 CURE extra credit consent (2).pdf, Category: Consent Form;<br>• 2.10.21 CURE gift card consent (2).pdf, Category: Consent Form;<br>• 2.10.21 CURE protocol (2) (1).docx, Category: IRB Protocol;<br>• 2.10.21 EC script instructors.pdf, Category: Recruitment Materials;<br>• 2.10.21 GC script instructors.pdf, Category: Recruitment Materials;<br>• CURE Survey (3).pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); |

IRB approval for Chapter 5:

ASU Knowledge Enterprise Development

APPROVAL: MODIFICATION

Sara Brownell
CLAS-NS: Life Sciences, School of (SOLS)
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Sara.Brownell@asu.edu

Dear Sara Brownell:

On 11/18/2020 the ASU IRB reviewed the following protocol:

| | |
|---|---|
| Type of Review: | Modification / Update |
| Title: | Exploring why students leave research and interviews of students with disabilities, students with depression, and transfer students. |
| Investigator: | Sara Brownell |
| IRB ID: | STUDY00007247 |
| Funding: | Name: SOLS: Undergraduate Programs |
| Grant Title: | None |
| Grant ID: | None |
| Documents Reviewed: | • 20.11.13_Interview_Follow-Up_Disability.pdf, Category: Recruitment Materials;<br>• 20.11.13_Supplemental-Interview-Questions_Disability.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);<br>• 20.11.18_Follow-up-Interview-Consent-Statement_Disability.pdf, Category: Consent Form;<br>• 20.11.18_UG Research IRB.docx, Category: IRB Protocol; |

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