

# **Resource Use and Success in Life Science Graduate Education**

**A Dissertation Presented for the  
Doctor of Philosophy  
Degree  
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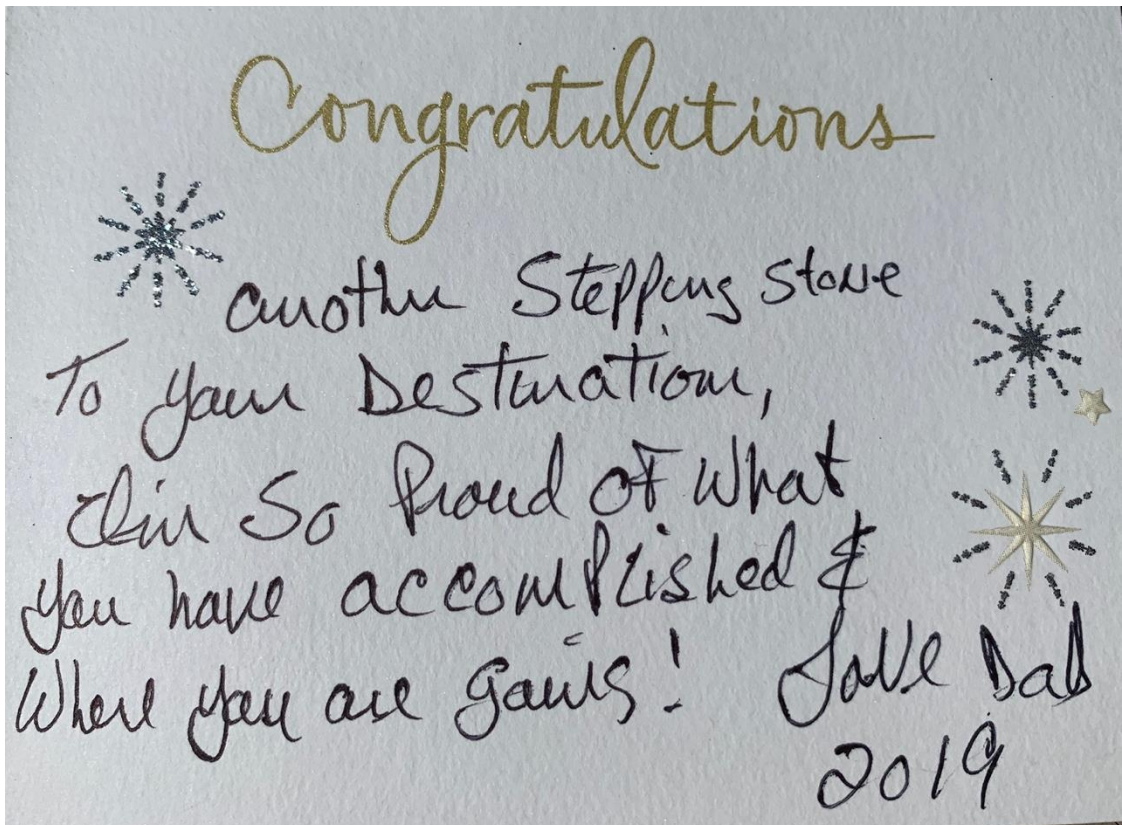
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## DEDICATION

This dissertation is dedicated to my dad, who took his own life in the second year of my PhD. He won't be here to see this, but he knew I'd make it here anyways.

Miss you. Love you.

*John A. Weatherton (June 22, 1959 – September 25, 2020)*



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## ABSTRACT

Given that attrition rates for Science, Technology, Engineering, and Math (STEM) graduate programs have been higher than 50% for more than a decade, increasing student success in graduate programs has long been a focus of research in higher education. However, previous research has paid little attention to the opinions and experiences of graduate students themselves. Graduate students' lived experiences may be critical to understanding factors driving graduate attrition and to improving STEM graduate programs broadly. This dissertation explored two understudied aspects of the graduate student experience: students' definitions of success and their use of resources.

I used interviews and surveys of graduate students to provide evidence that 1) life science graduate students have diverse definitions of success that include many different components, like happiness, achieving goals, and resilience. 2) Life science graduate students used many different resources, and differences in resource use and resource perception were associated with demographic factors, such as race and year in program. For example, nonwhite students reported using institutionally provided resources significantly more often than white students. 3) Life science graduate students' perception of resource value was driven primarily by the type of help they expect to receive from a resource, and the suite of highly valuable resources identified by graduate students is not aligned with current discussions of resources in the literature. Overall, results from my dissertation indicate that life science graduate students' experiences are critically underreported in the literature, from their definitions and experiences related to success, to the resources they use and why they use them, highlighting the critical need to add these voices to the literature.

Results from this dissertation will be useful for students, advisors, researchers, and institutional leaders. These results may be used to inform policy and mentoring decisions and future research into how graduate students may leverage resources to achieve success, however they define it.

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## INTRODUCTION

The aim of my dissertation was to explore the unexplored aspects of the graduate student experience – the things that graduate students *know* but haven't been studied empirically. Without this empirical work, voices of the less powerful (i.e., students) are often discounted in favor of 'how it's always been done,' without these inputs, we lose the information and lived experiences that can help to transform and improve systems. Thus, the overall goal of my dissertation was to shed an 'empirical light' on the aspects that many in the community already know in order to gain the legitimacy and authority needed to make recommendations to improve the student experience. The specific aspects of the student experience I chose to shine a light on are twofold: definitions of success and student resource use. I first investigated how 'success' is defined in higher education and how graduate students define success for themselves. Furthermore, I investigated what resources students use in their graduate programs and why they use them. These topics are intuitively linked; if one wants to know what resources students use to be successful (Chapters 3 and 4), you first have to know how students define success (Chapter 2). In preparing for that research, one is bound to discover at least some of the many inequities baked into higher education, like the hegemonic power that the term 'success' has exerted over the past century (Chapter 1).

Chapter one, "*Success for All? A Call to Re-examine How Student Success Is Defined in Higher Education*" was an essay that utilized a small literature review to examine how the term 'student success' has historically been defined in higher education research. In this chapter, I drew on ideas from Critical Race Theory and works from philosopher Antonio Gramsci on cultural hegemony to argue that defining student success as exclusively a measure of academic merit is one way that majority groups have exerted "soft power" over minoritized groups in academia. The essay suggested that broadening our definitions of success and allowing student voices to lead this effort are ways to combat hegemonic norms and begin the process of institutional change. This chapter closes with recommendations for policymakers and institutional leaders, as well as a discussion of how to best enact change in large academic institutions.

Chapter two "*Exploring Student Perspectives: How Graduate Students in a Life Science Department Define Success*" was a qualitative examination of graduate student definitions of success and the first of its kind in the field. Utilizing interpretive phenomenological analysis as a theoretical and methodological framework, this study explored how ten life science graduate students defined success and how those definitions changed over time. This study found that student definitions of success included multiple components (i.e., sub-definitions), and that these components were rarely similar among students. These components included academic success, career success, success that was aligned with students' values, gaining skills, achieving goals, happiness, and resilience. While most students' definitions of success included some aspect of academic success, many students expressed feeling guilty that their definitions of success were not wholly academic, and ashamed to share these non-academic components with their advisors. This chapter closes with recommendations for advisors and graduate students, with a focus on enabling students to feel more comfortable sharing their definitions of success to improve student well-being and, ultimately, help students achieve success.

Chapter three, *“Demographics Matter: Non-white and White Life Science Graduate Students Perceive and Use Resources Differently”* drew on Expectancy-Value Theory to examine which resource graduate students used in their program and whether a relationship existed between students’ resource use and their demographic characteristics. Specifically, this study defined resource use as students’ frequency of resource use and their perception of resource usefulness, and collected data related to the following demographic characteristics: student year in program, gender identity, racial identity, college-generation status (i.e., first- or continuing-generation college student). Data were drawn from a national survey of life science graduate students and relationships between demographics and resource use were modeled using ANOVA models and Tukey post-hoc analyses. Results showed that the most frequently used and most useful resource was students’ academic stipend (i.e., their income), followed by their advisor, lab mates, and significant others. Of the 34 resources surveyed, generally social resources were used more often and were perceived as more useful, while institutionally provided resources (e.g., university-sponsored events, workshops, career centers) were generally perceived to be less useful and were reported to be used less frequently by participants. Furthermore, results of this study revealed interesting relationships between certain demographic variables—notably race and year in program—and students’ use and perception of resources. For example, ANOVA modeling showed significant relationships between students’ race and their frequency of use of 13 of the 34 resources surveyed; generally, we found that nonwhite students reported using institutionally provided and social resources more frequently than white students. This chapter discusses how results can be applied to future research and to efforts to improve graduate programs nationwide.

Chapter four, *“I don't know what I would do without it” How life science graduate students describe resource value*” was a qualitative examination of what drives life science graduate students’ perception of resource importance. Chapter four built on work from previous chapters; utilizing the same national sample as Chapter three, this study asked participants to choose their three most important resources and then describe why each was important to them. Results from this Chapter revealed that, across all participants, advisor was the most frequently selected as students’ most important resource (selected by 68% of the sample), followed by academic stipend (57%) and significant other (25%). Advisor was the only resource selected by the majority of our sample, and 31 of the possible 34 resources were selected by at least one participant as their ‘most important resource,’ highlighting the diversity in student perspectives and perceptions of resource value. Drawing on Expectancy-Value Theory for Help Sources, qualitative examination found two themes in students’ responses. Students felt that resources were important because of some aspect of the resources’ attribute (e.g., its accessibility or validity) or because of what the resource provided to students (e.g., academic help, social support). The ‘help provided’ theme was far more common than ‘resource attributes,’ comprising more than 75% of overall codes assigned. Interestingly, we found no significant relationship between students’ demographic characteristics and their perception of resources (i.e., the codes assigned to their free response), nor did we find any significant relationship between students’ demographic characteristics and the resources they chose as their top three most important. Based on these results, I proposed a novel framework for understanding graduate students’ needs during their programs, which I termed an ‘academic hierarchy of needs’. This framework, along with qualitative results from this study, give voice to graduate students’ diverse and distinct

needs. By attending to these needs, I argue, students will be more likely to be both academically and personally successful during their graduate programs.

Overall, results from these four pieces of scholarship suggest that 1) in order to best support students, gathering and validating student voice must be the first step, and in gathering student perspectives, novel discoveries can often be made; 2) graduate students are a unique population, separate from undergraduates or those in the workforce, and thus, their needs, perspectives, and expectations must be studied and attended to individually; and 3) much more work is needed to fully understand the nuances of graduate student resource use and how resources may be leveraged to address equity gaps in higher education.

# **CHAPTER 1 SUCCESS FOR ALL? A CALL TO RE-EXAMINE HOW STUDENT SUCCESS IS DEFINED IN HIGHER EDUCATION**

A version of this chapter was originally published by Maryrose Weatherton and Elisabeth E. Schussler. Vera:

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This article was revised to match the formatting requirements of the University of Tennessee-Knoxville. Maryrose Weatherton was the main author of this article and was involved in all aspects of research ideation, data collection, and writing. Elisabeth E. Schussler is a coauthor and was involved in research ideation and writing.

## **ABSTRACT**

A central focus in science education is to foster the success of students who identify as Black, Indigenous, and people of color (BIPOC). However, representation and achievement gaps relative to the majority still exist for minoritized students at all levels of science education and beyond. We suggest that majority groups defining the definitions and measures of success may exert “soft power” over minoritized student success. Using a hegemonic and critical race theory lens, we examined five years of research articles in *CBE—Life Sciences Education* to explore how success was defined and measured and what frameworks guided the definitions of student success. The majority of articles did not explicitly define success, inherently suggesting “everyone knows” its definition. The articles that did define success often used quantitative, academic outcomes like grade point average and exam scores, despite commonly cited frameworks with other metrics. When students defined success, they focused on different aspects, such as gaining leadership skills and building career networks, suggesting a need to integrate student voice into current success definitions. Using these results, we provide suggestions for research, policy, and practice regarding student success. We urge self-reflection and institutional change in our definitions of success, via consideration of a diversity of student voices.



## INTRODUCTION

Within the United States, there has been a substantial increase in minority populations over the last 10 years, with the United States projected to be “majority minority” by 2045 (Vespa et al., 2018). However, this demographic shift has not been mirrored within the scientific disciplines in higher education; while more than 30% of the U.S. population identifies as Black, Indigenous, or other person of color (BIPOC), those groups represent only 21% of science, technology, engineering, and mathematics (STEM) bachelor’s recipients. Furthermore, BIPOC only represent 13% of STEM doctoral recipients, 11% of the STEM workforce, and 4% of R1 faculty (National Science Foundation [NSF], 2018). The trend is similar within the domain of biological sciences, where BIPOC students represent 12% of earned doctorates and 11% of postdoctoral fellows (Meyers et al., 2018). These differentials in degree acquisition and faculty representation can cascade down to undergraduate and secondary education students. For example, universities lacking diversity in their faculty ranks may see increased stereotype threat to BIPOC students (Nouwen and Clycq, 2018; Park et al., 2020). This can inhibit students’ development of a sense of belonging (Good et al., 2012; Hurtado et al., 2015), and negatively affect students’ persistence, well-being, and academic achievement.

Differentials in student success have been discussed for at least a quarter century within education research (Panos and Astin, 1968; Boland et al., 1978; Leman, 1999), with countless interventions, theoretical models, and diversity initiatives proposed to increase the success of BIPOC students at all levels STEM education. However, the state of BIPOC representation and persistence would suggest that these initiatives have not succeeded within STEM domains broadly or the field of biological sciences specifically. We argue in this *Essay* that the assumed definition of “success” and its associated metrics may be one factor hindering the very success of the populations we seek to advance.

### WHAT IS SUCCESS?

To study and facilitate student success, we must first understand what we mean when we say “success.” As with other broad terms like “interest” (Rowland et al., 2019), the term “success” has a variety of meanings both within and outside the domain of biology education. Student success can be seen in terms of *outcomes*, like persistence, increase in self-efficacy, and publication rate. However, these concepts can just as easily be seen as components that *facilitate* success if it is defined as achieving a particular goal. Furthermore, there can be a stark difference in how faculty and students define success (Dean, 1998; Thompson and Jensen-Ryan, 2018), as well as how minoritized students (which we use here to include BIPOC, first-generation, low-socioeconomic status, or other underrepresented groups of students) and their majority counterparts define the term (Tierney, 1992; Goyette and Xie, 1999; Oh and Kim, 2016; O’Shea and Delahunty, 2018). For example, in a study at a public California university, Oh and Kim (2016) found that Korean-American undergraduate students most often defined success as reaching the highest levels of academic achievement, while Mexican-American students most often defined success as going to a 4-year university, surpassing the success of their parents, and helping future students find success (Oh and Kim, 2016). These definitions were further aligned with different support needs and levels of student satisfaction. Thus, the meaning of student success depends on the context as well as who you ask, making a singular, unifying definition largely impossible.

Within biology education, we believe that our current definitions of success may lack the requisite diversity to fully capture the contexts of all students. These definitions inform the metrics used in, and conclusions drawn from, empirical research in the field. These, in turn, inform the policies and practices we advocate for, which ultimately affect student outcomes (Figure 1). These definitions are most often created and maintained by those who hold power in the field (e.g., researchers, faculty members, deans, and other university staff), and rarely include meaningful student input, especially from minoritized populations. If these definitions are not created *by* and *for* a diverse population, then there will be cascading impacts on outcomes for those left out of the conversation.

We argue that our current limited discourse around the meaning of student success is maintained, in part, by social hierarchies that can be examined through the lens of hegemony and critical race theory, which are described in the next section. These forces unwittingly reinforce and reproduce social hierarchies within our education system that may hinder the success of certain student populations who may not define success in the same way the majority does. Thus, we argue that a critical evaluation of success within higher education is imperative. In this *Essay*, we hope to start a conversation surrounding what success means, who should define it, and how an expansion of our definitions may help to facilitate the success of all students (Figure 1.1, listed in the Appendix at the end of this chapter).

### ***WHY SOCIAL HIERARCHIES ARE RELEVANT TO THE DEFINITION OF SUCCESS***

The ideas presented in this *Essay* assume an institutional reproduction of social hierarchies and are framed by cultural hegemony and critical race theory. Gramscian hegemony is used to explain the power relations between dominant and minority groups. Specifically, it explains the ways in which dominant groups exert “soft power” over nondominant groups to secure and maintain control within society (**Gramsci, 2000; Borg et al., 2002**). This is accomplished via manipulation of cultural beliefs, language, values, and norms to establish the dominant group’s worldviews as universal, natural, or common sense. These understood rules of society are often invisible, yet powerful. Alternative perspectives, norms, and values are actively discredited by making them seem counterintuitive or unnecessary (**Grimm, 2015**). However, these counterhegemonic ideas are often the values and perspectives held by nondominant members of society. Hegemony is thus maintained, because one cannot hold dissenting ideologies and also achieve social mobility, reinforcing existing social hierarches and forcing minority groups to conform to these dominant structures (**Dawson, 1982; Gramsci, 2000**).

We can examine the hegemonic forces underlying student success using ideas from critical race theory (CRT). CRT challenges dominant narratives around race and racism in education and identifies how these narratives are often used to subordinate minoritized groups and maintain white supremacy in the United States (**Solorzano 1997; Yosso, 2005; Ladson-Billings and Tate, 2006**). **Solorzano and Yosso (2001)** point out that racial stereotypes form the basis for the dominant “deficit notions” of BIPOC. For example, a common narrative in the United States is the idea of meritocracy, or “pulling yourself up by the bootstraps,” whereby minoritized groups can find success if they work hard enough (**Collins, 2018; McGee, 2020**). This narrative shifts blame for unequal outcomes (e.g., wage gaps, lowered academic persistence and achievement) to minoritized groups who “don’t work hard enough” or are deficit in some other way, instead of recognizing the structures and institutions that center power with the

majority. Within academia, these stereotypes establish a cultural norm that is upheld through differences in expectations, school funding, and punishment between BIPOC and white students (i.e., the school-to-prison pipeline; **Solorzano, 1997; Barnes and Motz, 2018**). While seemingly inert, these dominant frameworks translate into policies and structures that harm minoritized students (**Solorzano and Yosso, 2001**). For example, school tracking systems (**Rosenbaum, 1976; Southworth and Mickelson, 2007**), intelligence testing (**Rose, 1976; Solorzano and Yosso, 2001**), and disparate resource availability (**Tate, 2008; Green et al., 2017**) have historically been used to maintain social hierarchies by advancing the education of white students while justifying modern-day segregation and deficit notions of BIPOC students (**Solorzano and Yosso, 2001; Yosso, 2005; McGee, 2020**). Using a CRT lens allows us to explore how our current definitions and metrics of success do not come from neutral, unbiased, or meritocratic ideals, as is often assumed; instead they have been founded on racist principles. We believe that acknowledging this is an important first step to counter these hegemonic forces and begin to redress the harm that they have done to our students.

Linking hegemony and CRT to the concept of student success, we see that majority power can be maintained in higher education by normalizing a restrictive view of student success (e.g., success as having a high grade point average [GPA]). By focusing on outcomes like productivity and employability, these dominant definitions of success ignore large parts of students' well-being (e.g., social, cultural, or personal outcomes). This can be harmful to students who hold "alternative" definitions of success by making them feel as if they do not belong within academia (**Hurtado and Carter, 1997; Hurtado et al., 2015; Goyette and Xie, 1999; Tibbetts et al., 2016**). For example, in a study of Latinx undergraduates, **Hurtado and Carter (1997)** found that students' GPAs were not significantly associated with their sense of belonging. For these students, participation in nonacademic activities like membership in religious or community organizations was significantly related to students' sense of belonging (**Hurtado and Carter, 1997**). This example suggests that a focus on academic metrics versus other measures, such as social participation, may impede the retention of some minoritized students. Many CRT scholars have noted that within the United States education system, BIPOC students are forced to "assimilate" into dominant, Eurocentric paradigms, including those surrounding work ethic, educational values, and definitions of achievement (**Carter and Segura, 1979; Solorzano and Yosso, 2001; McGee, 2020**). Minoritized students in academia are thus faced with two choices: integrate into an environment that is misaligned with their identities and actively discredits their beliefs or leave the system (**McGee, 2020**). When they choose to leave, this attrition of minoritized students from academia not only prevents the field of biology from achieving diversity and equity goals, but it also limits minoritized students' social mobility and therefore reinforces existing social hierarchies.

Certainly, we do not think that institutions or educators who promote individual, quantitative definitions of success do so as an active choice to suppress minoritized students. Because hegemonic power flourishes when cultural norms are taken for granted, ideas of what makes a student successful are often built into our academic systems and assumed to be universally true. Even when educators and researchers may wish to reimagine how success is defined and evaluated, institutional structures like yearly evaluations based on pass/fail rates or GPA requirements for degree progression may leave little room for them to introduce "alternative" definitions of success, such as positive mental health, internal development, or

community-based outcomes. Education researchers, as intellectual leaders in the field, have an opportunity to examine and resist dominant social hierarchies by refusing to support hegemonic structures while voicing counter-hegemonic structures and narratives. Foucault (1997) suggests that the “reproductive power” of cultural hegemony can be resisted and fought against through critical discourse and inviting new voices into the conversation. It is indisputable that academic definitions of success are both relevant and useful within higher education; however, we argue that alternative views of success must be normalized to advance institutional and societal goals. Thus, by listening to new voices (e.g., amplifying minoritized students’ views of success) and considering new definitions of student success, education researchers can take the first step toward changing the system that is preventing students from achieving success equally.

## HOW BIOLOGY EDUCATION RESEARCHERS DEFINE SUCCESS

One window into the discourse around student success can be found in the empirical literature investigating student success in higher education. We believe that current definitions of student success are limited, and that this is true across STEM domains. However, we have chosen to support our argument by sampling the literature within the domain in which the authors have the most knowledge—biology education. To sample how success is discussed and defined in the literature specific to this domain, we explored education research articles that discussed student success in *CBE—Life Sciences Education (LSE)* over the past 5 years. We examined 1) whether and how success was explicitly defined within research articles and 2) how success was measured. We also noted what theoretical frameworks seemed to be shaping research on student success. This literature examination was restricted to biology education and not intended to be comprehensive. Instead, this examination is used as an example of how probing the term “success” can reveal a need for researchers to re-examine their assumptions as well as consider how different metrics and a diversity of student voices may lead to a more complete definition of what it means for students to be successful.

We used a standard literature review methodology to collect these data (Creswell and Creswell, 2017). We searched the online database of *LSE* on June 14, 2020, using the term “success,” and limited our search to articles published within the last 5 years (2015–2020). This primary search returned 311 articles, which we further narrowed by selecting only research articles (i.e., not reviews, meeting reports, or editorials). After applying this filter, we were left with 248 results.

As we were specifically interested in how success was defined in higher education, we excluded articles that examined student success in K–12 educational settings. Furthermore, we excluded articles that evaluated the success of specific curricular programs (e.g., research examining the success of an intervention aimed at reducing gender bias) as opposed to research on student success, as well as research papers about instructors and faculty, as they did not explicitly study *student* success. We did not have any exclusion criteria related to subject domain (e.g., math success, physics success, etc.) though most articles published in *LSE* are related to life sciences education. We also did not exclude any articles on the basis of study time frame or analysis approaches. This left 52 articles related specifically to research on student success in higher education over the last 5 years (see the Supplemental Material for the list of these articles).

### ***THE MAJORITY OF ARTICLES DISCUSSING STUDENT SUCCESS DID NOT EXPLICITLY DEFINE THE TERM***

Of the 52 articles, 21 (40%) gave explicit definitions of student success. The other 31 defined student success implicitly through the variables they measured, often equating student success with quantitative student outcomes, such as exam scores and GPA. Of the papers that explicitly defined success, there were four broad categories for how the concept was defined: academic, persistence, career, and social (see definitions in **Table 1.1, listed in the Appendix following this chapter**). Academic definitions (e.g., grades, GPA) were the most prevalent in the literature (80%), followed by persistence (e.g., remaining in major) definitions (47%). Career definitions included obtaining a job in STEM (15%). The least common category was social definitions (4%), with only one paper explicitly defining success as it was related to students becoming leaders in their communities. Each article with an explicit definition could be placed in one or more of these four categories.

### ***THERE WERE MANY DIFFERENT WAYS TO MEASURE SUCCESS, AND MOST WERE QUANTITATIVE***

Overall, there were 30 distinct measurements of student success in the articles, 13 of which were mentioned more than once. The majority of papers (88%) measured at least one quantitative outcome related to student success; only six papers captured solely qualitative metrics. Of the papers that measured quantitative outcomes, the most common measure of student success was a suite of persistence measurements, followed by exam scores and course grades (**Table 1.2**).

Persistence as a measure of student success came up often and in many different variations in the articles. In total, 20 articles (38%) measured student success as some aspect of persistence, attrition, or retention (**Table 1.2**). We separated these into five subcategories based on the authors' description of the outcome variable. Articles that reported "retention" and "persistence" *generally* were sorted into the first subcategory: "persistence/retention general." Most often, papers in this subcategory measured persistence or retention in a degree program. Further, "persistence/retention in major" and "persistence/retention in a STEM field" were two different subcategories, with the former being explicitly about changes in students' declared major, while the latter included postgraduation outcomes, like attaining a career in a STEM field or continuation to a STEM graduate degree. The outcome "intention to persist/remain" was based on student expectations versus actual retention or persistence from a major or course. Finally, there was only one article within the subcategory of "attrition" (**Wilson et al., 2018**); this article measured the percent of graduate students that left their programs without an MS or PhD degree over a period of 8 years.

### ***THEORIES OF STUDENT SUCCESS HAVE CHANGED OVER TIME***

As part of the framing for their student success studies, many of the articles cited one or more theories or theoretical frameworks that guided their work. Across the articles we examined,

23 theories were cited, and five were mentioned within multiple papers: self-efficacy, identity, sense of belonging, social cognitive career theory, and social interdependence theory. Theoretical frameworks can influence almost every aspect of a study, from how the research questions are framed, to how concepts are understood and defined, what data are collected, and how the results are interpreted and situated within the broader field (**Anfara and Metz, 2014**; **Creswell and Creswell, 2017**; **Rowland et al., 2019**). In studies of student success, the theoretical frameworks that researchers chose likely influenced how they defined success or the success outcomes they hoped to measure. These theoretical frameworks, then, can be vehicles of hegemonic influence that set the standard for how student success is measured and discussed and are thus integral to consider. We will discuss the evolution of the discourse around student success in order to add context to these frameworks and inform our discussion about how to expand our definitions of success.

Although the term “student success” has been discussed in the education literature for more than a century (**Carmichael, 1913**; **Alexander and Woodruff, 1940**; **Brogden and Taylor, 1950**), most of the theories or frameworks mentioned in the articles we examined were more recent in origin. The five most commonly cited theories in the articles originated within the biology education literature over the past 30 years. However, this empirical research was built on work done in the past, meaning that even these newer conceptions can have old ideas embedded in them that perpetuate racist stereotypes and ideals.

Popularized in the 1950s and 1960s, universal quantitative measures (e.g., ACT, Scholastic Aptitude Test, Graduate Record Examination scores) were some of the first measures of student success (**Capps and Decosta, 1957**; **Kunhart and Olsen, 1959**). Early theories of student success proposed success as an outcome based on inherent qualities, like personality (**Robertson and Hall, 1964**). In the 1970s and 1980s, work on student socialization and integration popularized one of the most commonly used metrics of success, persistence (**Table 1.2**). Theories during this time built upon previous work by examining how students’ personal characteristics impacted their interactions with their environments, like **Tinto’s (1975)** theory of student attrition. As the “positive psychology” movement gained traction in the 1990s and 2000s, more modern theories layered “internal development” factors, like motivation and self-regulation, on top of the interactions among personal characteristics and proximal environmental influences to explain student success. For example, social cognitive career theory claims that increasing students’ feelings of self-efficacy and providing them with relevant learning experiences can mediate background and proximal environmental influences on their career decisions and goal attainment (**Lent et al., 2002**). This layering introduces new ideas but retains core older ideas about student success.

While new ideas of success push the field forward, much of the discussion is still framed by antiquated, racist notions that undermine these theories’ ability to reflect the experiences of BIPOC students. For example, Binet’s IQ test has been used to justify “genetic determinism” models of minority education equality (**Rose, 1976**; **Solorzano and Yosso, 2001**). And although the field’s most influential theories are assumed to be broadly applicable, many of them were developed solely on the basis of majority students. For example, Tinto’s influential institutional departure model (**1975**) has been critiqued for its exclusive study of “traditional” students (i.e., white, upper-class students) at “traditional” universities (i.e., primarily white, residential, 4-year institutions; **Astin, 1985**; **Attinasi, 1989**; **Tierney, 1992**; **Tinto, 1993**). These limited

populations bounded the results drawn from the theory. This has led, for example, to the problematic conclusion that students must detach from their previous communities in order to find success in higher education. Indeed, the opposite has been found for minority and first-generation students, many of whom draw strengths from their connection to their home communities and cultures (**Muñoz and Maldonado, 2012; Yao, 2015; Burt et al., 2019**).

The use of majority students as the foundation for the theories central to the ideas underlying student success is not only problematic, but harmful to minoritized students. When historically underrepresented students do not meet the standards of success established by the theories (e.g., higher attrition rates, lower course grades, etc.) it is assumed that the deficiencies are on the part of the students, and not the theory. As previously mentioned, this “deficit notion” of BIPOC students prevents equitable outcomes between BIPOC and white students. It also forces minoritized students to choose whether to conform to the majority standards of success or live within a system that does not value what they consider to be successful.

Despite the expansion of our theoretical understanding of student success over the past century, many of our definitions and metrics of success have been stubbornly unchanging. We acknowledge that the practicality and ease of quantitative metrics may be one reason why they are so prominent when measuring student success. It takes much less time to gather the course grades of each student in an introductory biology class than it does to collect interview data about their perspectives on success in the course, for example. Furthermore, latent constructs like student well-being or identity are more difficult to measure compared with academic metrics like GPA, as the former are made up of multiple, diverging indicators, and alternative ways to measure these constructs may not yet have been developed and validated for wider usage. Of course, quantitative metrics can have predictive value and can be excellent tools to answer many research questions. However, we argue that measuring quantitative outcomes is not a panacea for understanding how students achieve success in academia. Thus, we argue that, without addressing the ideas that underlie our notions of success, the field will continue to struggle to address the needs and facilitate the success of all of our students.

## WHO GETS TO DEFINE STUDENT SUCCESS?

Of the 52 articles in *LSE* that discussed student success over the past five years, only *one* article captured students’ own definitions of success, suggesting a paucity of research in this area. This presents an issue if students have different definitions of success than those who determine the field’s definitions, like researchers and institutional decision makers.

Indeed, **Thompson and Jensen-Ryan (2018)** found that undergraduate students expressed definitions of success that included academic outcomes like graduation as well as emotional outcomes, such as not getting discouraged and increasing their self-efficacy and self-confidence. Many students from historically underrepresented backgrounds (e.g., BIPOC, low-socioeconomic status, first-generation students) reject traditional definitions of success. For example, **O’Shea and Delahunty (2018)** found three themes of success that emerged from interviews with first-generation undergraduates: success as a form of validation, success as defying the odds, and success as positive feelings about one’s trajectory. Interestingly, many of the students interviewed had very clear ideas of what success *was not*, including obtaining high grades or passing exams (**O’Shea and Delahunty, 2018**).

Considering these examples of how students' and researchers' perspectives on success can differ, we ask why student voices are so rare in the literature on student success. One explanation goes back to the idea of hegemonic power, wherein members of the majority impose their worldview as cultural "common sense" (**Boggs, 1976**, p. 39). Within academia, hegemonically imposed worldviews can present themselves via the belief that definitions of certain terms are homogeneous and that explicitly defining terms like "success," "persistence," and "interest" is not necessary. Indeed, our examination of the literature on student success found that success was only *explicitly* defined in 40% of the articles we examined. Even when success is defined, researchers and other institutional stakeholders may experience difficulty thinking beyond traditional definitions, as they often realized their positions via traditional success measures (e.g., academic success). Thus, the problem becomes apparent—if most researchers define success in similar ways, and these definitions are validated by achieving intended career outcomes, then these definitions are taken for granted and seen as common sense. Therefore, researchers may not see the need to gather student perceptions of any concept whose definition seem so inherent.

In this way, hegemonic influence is hidden within everyday facets of academia, like the language we use to describe and define concepts. However, a critical examination of the discourse surrounding these concepts can reveal a startling lack of ideological diversity. We argue that the hegemonic framing of embedded discourse prevents the field from moving forward toward more inclusive definitions and metrics. To resist this framing, we must collectively examine and make concrete changes to many of the aspects we have discussed here: how success is defined and measured and whose success we are concerned with. As a community of researchers, we have the collective power to expand our own and our institutions' discourse in order to validate and facilitate all students' definitions of success. To that end, we present recommendations in the realms of research, policy, and practice that aim to amplify minoritized student voices, encourage deep self-reflection, and bring about equitable institutional change.

## RECOMMENDATIONS

The purpose of this *Essay* was to examine success through a hegemonic and CRT lens to inform a collective discussion about how our current perspectives on student success may be contributing to unequal attainment of success. Despite a concentrated effort over the past 25 years to increase BIPOC "success" in STEM domains, gaps between BIPOC students and their majority counterparts still exist at all levels of STEM education and beyond (**NSF, 2018; Meyers et al., 2018**). Although the field's ideas and theories of student success have evolved and gained more nuance over the past 70 years, our definitions and measures still fall short of being fully inclusive. Our limited examination suggests that current definitions and metrics of student success are mostly academic and quantitative and are most often defined by institutional-level stakeholders, such as researchers. Although these theories were developed via research directed at students, there is a paucity of literature that directly asks students their views on success in higher education. Here, we propose recommendations for individual researchers to more explicitly consider success and center student voice in their empirical work. We then provide recommendations for the community as a whole within the areas of research, policy, and practice.



## **RECOMMENDATIONS FOR INDIVIDUAL RESEARCHERS**

To encourage researchers to more critically examine their potential role in the reproduction of social hierarchies in academia, we recommend that they consider their own definitions of student success and how these definitions influence their empirical work. Furthermore, we encourage researchers to consider what definitions of success are highlighted within their research and how they can amplify diverse perspectives and voices within that research. Explicitly considering what perspectives of success they intend to use before beginning their projects will allow researchers to clearly ground their work and accurately describe what they intend to study, which in turn will lead to clarity in definitions, proposed metrics, and interpretation of results.

To foster these reflections, we model from **Rowland et al. (2019)** the presentation of guidelines and associated guiding questions for researchers to use as they begin projects investigating student success in higher education:

1. Before beginning their research, researchers must self-reflect on the biases, hegemonic frames, and societal norms that they have internalized simply as members of society. Much like the qualitative practice of bracketing, this process will not rid researchers of any biases, but makes them visible, so researchers can reflect on how these biases may shape their interpretations (**Creswell and Miller, 2000**). For resources to guide self-reflection and examination of internal biases, see **Gullo et al. (2018)**, **Killpack and Melón (2016)**, **Project Implicit (2011)**, and **Racial Equity Tools (2020)**.
2. Researchers should discuss and agree upon their definition(s) of student success before beginning their research. This decision may be guided by funding sources, participant populations, research questions, and/or guiding theoretical frameworks. Questions:
  - i. Does my funding source require institutionally relevant data, like student retention or GPA? If so, does my definition align with these metrics? Do I need to add a second definition if I am collecting other metrics?
  - ii. How diverse is my intended study population? Are there definitions of success that may more closely align with the views of my intended population?\*
  - iii. How might my study accurately capture the perspectives of minoritized students, as opposed to invoking “safe multiculturalism” (i.e., an unchallenging, stereotypical, or tokenized view of a culture)? For more information on safe multiculturalism, see **May and Sleeter (2010)** and **Yancy (2016)**.
  - iv. Do my intended research questions and theoretical frameworks align with the definition(s) of student success I am considering?
3. Researchers should confirm that the intended metric(s) of success align with the chosen definition(s) within their project. Questions:
  - i. Based on my definition, how many measures of success do I need to use?
  - ii. Should the definition of success be captured using quantitative or qualitative metrics? If I can use both, is one more appropriate given my intended population,\* study context, and time constraints?
  - iii. Am I sure that students define success in the way I am intending to measure it?\*

4. Researchers should justify the reason for using their chosen definition(s) of success over others and acknowledge the limitations that their chosen definition(s) might present.

Questions:

- i. Have I chosen this definition of success over others simply because its associated metrics are easy to measure?
- ii. Have I explicitly defined success in any communications about my project?
- iii. Have I sufficiently articulated a rationale for my definition and measures?
- iv. How might the definition of success used in my project be a potential limitation of the study? Have I acknowledged that as part of the study?

\*If the answers to some of these questions are unknown, researchers may want to consider a pilot study or a qualitative inquiry into these students' definitions of success.

We hope the use of these guidelines and associated questions will help researchers appropriately conceptualize success in each study they undertake and encourage researchers to consider how to capture diverse voices and perspectives within their research.

### ***RECOMMENDATIONS FOR RESEARCH, POLICY, AND PRACTICE***

The following section focuses on actions the community can take to disrupt the current thinking about student success in order to reframe it for all students. To reflect the full diversity within STEM, and in consideration of the lack of student voice in the current literature, we suggest a need to truly listen to student perspectives on success at all levels. Lack of student voice is widespread across many domains; indeed, this issue has garnered the attention of the United Nations, which in 2009 proposed “General Comment No. 12—The Right of the Child to be Heard” ([UN, 2009](#)). In 2002, the UN Committee on the Rights of the Child (UNCRC) documented its concern that “in education, schoolchildren are not systematically consulted in matters that affect them” ([UN, 2002](#)). We suggest that similar issues are present in higher education, even though the majority of our students are considered adults.

In 2007, Lundy proposed a model to conceptualize article 12 of the UNCRC, and we are adapting it here to guide discussions about how to highlight student voice in research on student success and bring meaningful change within the realms of policy and practice (Figure 1.2). Article 12 delineates two key rights: 1) the right to be heard and 2) the right to have one's views given due weight ([Lundy, 2007](#)). To successfully implement article 12, Lundy proposed that four elements must be considered: space, voice, audience, and influence. The first two elements, space and voice, relate to students' rights to be heard. The next two elements, audience and influence, relate to students' rights to have their views given due weight. We propose that the first two elements of Lundy's model can be used to inform recommendations for research, and the latter two elements can be used to inform recommendations for research, policy, and practice.

## *STUDENTS' RIGHTS TO BE HEARD—RECOMMENDATIONS FOR RESEARCH.*

A prerequisite for meaningful engagement with students requires the recognition that their opinions are necessary and valid. In regard to discussions of student success, this means we must create space in our discourse where alternative definitions of success are not only allowed but are honored as equally valuable. We believe that the process of making this space can start with this *Essay* and subsequent conversations. This space will allow the field to begin the process of examining the current hegemonic structures that dominate academia and work to dismantle them.

Student voice is critical to this process. This can be accomplished either informally, through conversations between students and mentors; or formally, through qualitative research regarding how students define success. Involving students in the research process is an empowering way to amplify student voice in our discussion of student success. When applicable, we suggest that researchers employ a community-based participatory research approach, a research strategy that equitably involves community members and researchers in a way that seeks to validate community members' expertise and empowers non-researchers by sharing the decision-making process (see **Minkler and Wallerstein, 2011**). We also point out that the need to listen to students includes both undergraduate and graduate students. Research on graduate student success is even more limited than for undergraduates, and given the high attrition of graduate students from STEM degree programs (**Chen, 2013**; **Sowell et al., 2015**), it is important to also capture their unique perspectives. These conversations can add critical, new perspectives needed by researchers and institutional stakeholders to steer the field in a new direction.

*Students' Rights to Have Their Views Given Due Weight—Recommendations for Research and Policy.*

**Lundy (2007)** recognized that making space and gathering student voice do not necessarily mean that student perspectives will be appropriately heard or acted upon. Indeed, ensuring students maintain their rights is often difficult, especially when their views challenge the dominant thinking, are expensive to enact, or cause controversy (**Lundy, 2007**). It is important that we are attentive to the latter two elements in Lundy's model—audience and influence—as merely gathering student perspectives without enacting change (i.e., tokenizing student voice) will not combat systemic issues and may, in fact, be counterproductive (**Alderson, 2000**).

Students' perspectives must be presented to the appropriate audiences in order for them to have any influence over research, policy, or practice. Thus, stakeholders at all levels of academic institutions must be exposed to these voices. This can be accomplished broadly through publication and presentation of work that foregrounds student voice and locally through initiatives that present students' opinions to provosts, deans, department heads, faculty, and other university leadership staff to inform new policies. The UNCRC has warned that “appearing to ‘listen’ to children is relatively unchallenging; giving due weight to their views requires real change” (**UN, 2003**, para. 12).

Individuals (e.g., researchers, students, and staff members) must be engaged in the process of amplifying student voices and expanding our understanding of student success. However, for these recommendations to have lasting effects, the need to expand how success is defined and measured must be understood and enacted by academic institutions and organizations in the field (e.g., NSF, Association of American Universities, American Academy

for the Advancement of Science [AAAS]). We discuss this more in the following section. Further, while we present two broad policy suggestions, we urge policymakers to see students not just as respondents or data points, but as partners and cocreators in establishing appropriate policy that serves their unique student populations. For a more in-depth guide to including students in this process, see Lygo-Baker et al. (2019).

First, we suggest that universities have a policy to incorporate nonacademic measures of success into components of course work or within graduate student evaluations. Many studies have revealed that student mental health and persistence, among other outcomes, are highly impacted by nonacademic factors (i.e., not related to course or grade outcomes) such as creation of a professional network (Sweitzer, 2009), development of metacognitive regulatory strategies (Green and Macauley, 2007; Efklides et al., 2018; O'Shea and Delahunty, 2018), and establishment of students' academic identities (McAlpine and Amundsen, 2009; Oh and Kim, 2016; Schnoes et al., 2018). Depending on students' definitions of success, these factors may be as important, if not more important, than traditionally evaluated outcomes, like GPA, exam scores, or time to degree. This policy would work to honor alternative definitions of success and thus increase sense of belonging for all students in academia. Moreover, incorporating a larger diversity of success metrics will grant advisors, departments, and institutions a more holistic picture of student development and progress.

Second, we suggest that universities add or amplify nonacademic support for students that honors alternative definitions of success. The current hegemonic framing of student success encourages a large amount of institutional support to go toward facilitating academic definitions of success (e.g., tutoring centers, peer coaches, academic advising). While these supports are useful and integral to many students, support structures for nonacademic definitions of success can be equally important to students. Thus, we suggest directing more funding to services such as career centers, which support career-based definitions of success (Gallup, 2016); multicultural student centers and groups, which support community-based definitions of success (Bell, 2016; Tachine et al., 2017); and mental health support, which can work to support definitions of success that include personal growth and development (Biasi et al., 2017; Vescovelli et al., 2017). By truly listening to, and acting on, the unique voices of students, university leaders can enact changes in institutional policy and structure that may be more likely than current initiatives to facilitate success for all students.

### ***RETHINK, REFRAME, START A CONVERSATION—RECOMMENDATIONS FOR PRACTICE***

Our goals to increase representation of minoritized students in STEM, to improve student well-being, and to facilitate student success will only be met once all definitions of success are represented and supported in higher education. However, faculty play a role in everyday interactions with students that can be powerful influencers of success as well. Our perspectives, our biases, our words matter, and we need to carefully reflect on our individual influence. Do we think that graduate students are more successful if they become R1 faculty after graduation than if they become science journalists? Do we have a problem if undergraduates entering our classrooms see success as a “C” as opposed to an “A”? These biases, which come from our own backgrounds as students and researchers, are seemingly innocuous; however, they impact how we interact with students in one-on-one meetings, during office hours, and in the classroom, and

therefore impact how supported students feel. Noncontent talk, or the things instructors say that are unrelated to the course material (Seidel et al., 2015), could be an important way to expose students to multiple, diverse definitions of success or it may reinforce a hegemonic view of student success in university settings. Attention to our own thinking and words and how they impact our discussions with students may be key to breaking down the cycle of hegemonic reproduction in academia. Finally, it is important to acknowledge the difficult work involved in beginning to unpack and examine the facets of internalized racism that underlie the “simple” idea of student success. This work is necessary to move the field forward and build a more equitable environment with diverse conceptions of success.

### ***ENACTING CHANGE***

We recognize that raising awareness, encouraging self-reflection, and including student voice may not in and of itself change how success is framed. These steps may be critical to changing the perspectives of individual researchers and adding new definitions and metrics of success but may not be enough to change institutional structures that are deeply embedded in racist social hierarchies. Indeed, a central component of our critical race framework is the notion that racism is not an individual issue, but a deeply ingrained systemic condition (Ladson-Billings and Tate, 2006; Solorzano and Yosso, 2001; Vaught, 2011). Thus, in the following section, we highlight some ideas for institutions and organizations to enact lasting structural change as it relates to student success.

First, to properly enact change, we must acknowledge the concept of “empathetic fallacy,” or the incorrect idea that changes will be instituted simply because they are *the right thing to do* (Delgado and Stefancic, 2000). While making the field’s definitions and metrics of success more diverse and equitable *is* the right thing to do, this fact is not enough to shift hegemonic structures. Instead, we have provided a table of the benefits of and risks for not expanding our definitions and metrics of success, which we encourage the community to build on (**Table 1.3**). These benefits range from positive impacts on student well-being and retention, to more equitable institutional policies and practices and scientific problem solving. Indeed, Freeman and Huang (2015) found that greater author homophily was associated with publication in lower-impact journals and fewer citations, while the opposite was true with more ethnically diverse groups of authors. More diverse teams and institutions solve problems faster (Reynolds and Lewis, 2017), generate more creative solutions (Dezső and Ross, 2012), and are more resilient in the face of change (Duchek et al., 2020). Beyond the moral imperative for our field to become more equitable, we argue that combating the current hegemonic structures is essential for future innovation, advancement, and evolution of STEM fields. The risks of not applying these recommendations mirror the current issues with the field that we have discussed previously, including maintenance of social hierarchies, poor student mental health, and continued difficulties meeting diversity and equity goals at academic institutions and within society broadly (**Table 1.3**). However, we also must acknowledge that there are costs to these recommendations that also must be taken into account: institutions and individuals must invest time, resources, and emotional energy into enacting these changes.

Changing definitions of success will also require transformative change at the institutional level and beyond. This type of “deep change” or “second-order change” employs multiple change approaches to impact the attitudes, culture, and structure of organizations (Kezar, 2018) and dislodge the current hegemonic cultures, values, and beliefs that currently exist. Although individuals must change as part of this process (first-order change), second-order change involves explicit questioning of the operational frameworks and assumptions under which an organization functions, thus changing not just practices, but ideologies within an institution (**Argyris and Schön, 1997**; Kezar, 2018).

In the field of STEM education, the efforts to replace lecturing with active learning is one example of second-order change. The benefits of active learning have been known for many years. Early efforts centered on getting individual faculty to change their practices, assuming that diffusion of these innovations would spread active-learning approaches, which is not what happened (**Miller et al., 2000**; **Bennett and Bennett, 2003**; **Brownell and Tanner, 2012**). To foster broader change, the *Vision and Change* initiative was started by individuals who realized that the influence of national organizations such as the NSF, AAAS, and disciplinary societies could be used to amplify change (**AAAS, 2011**). A series of forums and conversations with colleges and universities were organized, exemplifying the second-order change principle of providing opportunities for ongoing collaborative reflection within an institution. National conferences brought together leaders in the field and produced two influential conference reports with data, ideas, and exemplars that individuals and organizations used as levers for change. This highlights another principle of second-order change, using data to illustrate the need for change. NSF actively encouraged research on *Vision and Change* principles, incentivizing individuals and institutions to prioritize these ideas. While efforts related to *Vision and Change* have not employed all of the recommendations we suggest in this paper (e.g., including student voice in reforms), we believe it is an illustrative example of institutional change that has made great strides in normalizing active learning as beneficial and lecturing as a potentially harmful to students (**Freeman et al., 2014**, but see **England et al., 2019**).

Within our discussion of changing definitions and metrics of success, we believe that similar expansive, enduring initiatives are needed. As seen in the case of *Vision and Change*, institutional efforts can be amplified by disciplinary societies, foundations, and government agencies. These external influencers can also provide broad policy suggestions and funding initiatives to support systemic change. These efforts are time-consuming, but they represent some of the approaches that would be necessary to change the values, beliefs, and institutional culture surrounding the concept of success.

## CONCLUSION

Student success is a central focus of education, particularly uncovering ways in which minoritized students can achieve representation in STEM at levels equivalent to their representation in U.S. populations. We posit that the lack of diversity in definitions and measures of success is an example of hegemonic influence within academia. Hegemonic power may be unknowingly upheld by researchers, faculty, and other institutional-level stakeholders who consider these dominant ideas of success to be “common sense” or standard. These dominant ideas of success, often stemming from racist structures and theories, reinforce social hierarchies within academia, making it more difficult for minoritized students to achieve social mobility (**Giroux, 1984**). Movements of counter-hegemony are the only way to subsume dominant

cultural norms (**Pratt, 2004**). Thus, we call on researchers to carefully consider their definitions of success and associated metrics, to fully acknowledge how their conceptualization of success impacts their research, and to make space for and solicit student voice in discussions of student success. We further call on institutions and faculty to consider a more holistic view of student success, and when presented with student voice, to not merely listen, but to give their perspectives “due weight.” And we call on disciplinary societies, government agencies, and other organizations in positions of power and influence to consider how they may play a role in fostering new definitions of success. Finally, we hope that this *Essay* sparks collective reflection that leads each of us to consider how we participate in hegemonic reproduction, what biases we operate under, and how we can work in our classrooms, with our advisees, and as advocates, to facilitate student success that is as inclusive as we strive to be.

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## APPENDIX 1

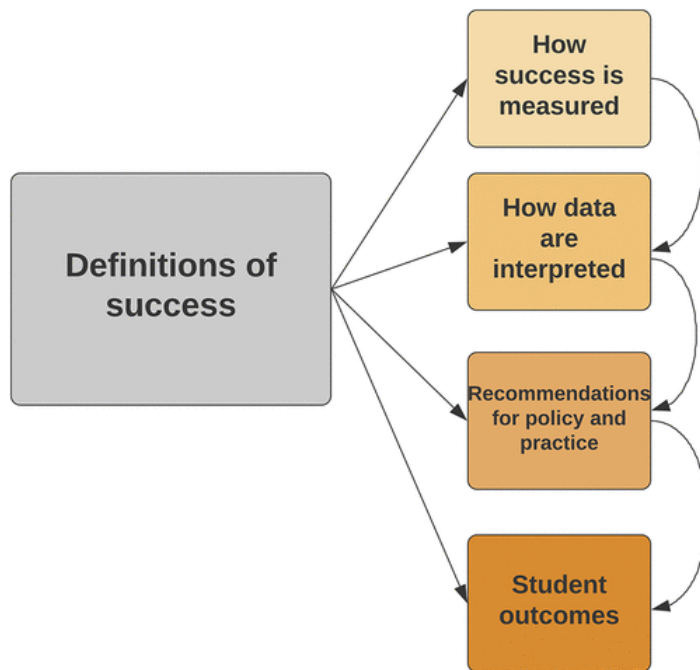


Figure 1.1: How success is defined impacts almost every facet of the research process, as well as policies and practices, and ultimately affects student outcomes. Researchers' definitions of success will impact how they choose to measure the construct, which in turn will impact how data are interpreted and thus what recommendations are proposed.

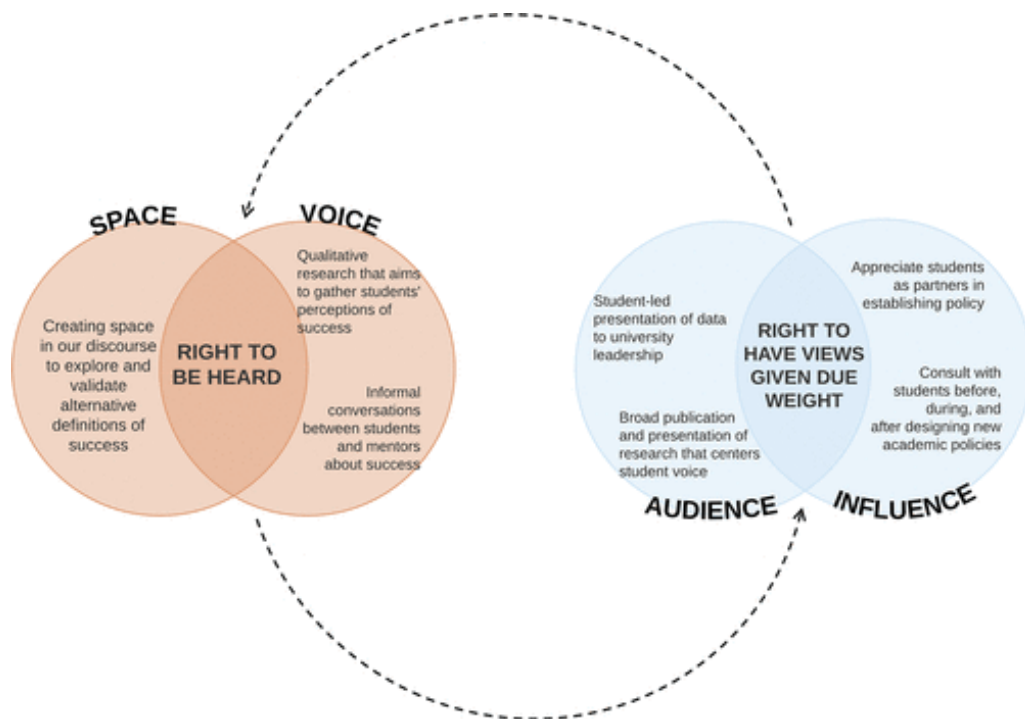


Figure 1.2: This figure highlights four key elements from Lundy’s model, two relating to one’s right to express a view—space and voice—and two relating to one’s right to have their views given due weight—audience and influence. These rights are highly interrelated.

Table 1.1: Categories of explicit definitions of student success represented in the literature sample (N = 21 articles that defined success explicitly out of 52 total articles)

| Category | Definition                                                                                   | No. of papers using | Representative quote                                                                                                                                                                                                                                                                                                                                   |
|----------|----------------------------------------------------------------------------------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Academic | Describe success as obtaining positive academic outcomes, like grades, GPAs, or exam scores. | 17                  | “Because we did not have an a priori prediction of whether delayed re-quizzing would help students with differing incoming biology knowledge (pretest score) or differing success in previous STEM course work (chemistry final exam score), we added both interaction terms into our model in step 3.” ( <a href="#">Walck-Shannon et al., 2019</a> ) |



Table 1.1 Continued

| Category    | Definition                                                                                                                        | No. of papers using | Representative quote                                                                                                                                                                                               |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Persistence | Describe success as students remaining in a major, program, or within STEM broadly.                                               | 10                  | “Success was defined as a student remaining in a course between registration and the end of the course and receiving a grade of “C” or better.” ( <a href="#">Gregg-Jolly et al., 2016</a> )                       |
| Career      | Describe success as some factor related to career outcomes, like obtaining a career in STEM or intention to pursue a STEM career. | 8                   | “Given that they [participants] had positions in research careers, all respondents were presumed to be successful.” ( <a href="#">Martinez et al., 2018</a> )                                                      |
| Social      | Describe success as some factor related to interpersonal relationships, like facilitating community leadership                    | 1                   | “Collective success underpinned the Āwhina kaupapa (goal) of producing STEM professionals who would become leaders in Māori, Pacific, and other minority communities.” ( <a href="#">Richardson et al., 2018</a> ) |

Table 1.2: Measurements of student success (outcome variables) represented more than once in the literature sample (N = 52)

| Outcome variable                  | No. of papers using this measure |
|-----------------------------------|----------------------------------|
| Persistence/retention/attrition   | 20                               |
| Persistence/retention general     | 9                                |
| Persistence in STEM field         | 5                                |
| Intention to remain in STEM field | 4                                |
| Persistence in major              | 1                                |
| Attrition                         | 1                                |
| Exam scores                       | 16                               |
| Course grades                     | 10                               |
| GPA                               | 9                                |
| Student attitudes                 | 8                                |
| Graduation/degree attainment      | 7                                |
| Number of publications            | 4                                |
| Self-efficacy                     | 3                                |

Table 1.2 continued

| Outcome variable   | No. of papers using this measure |
|--------------------|----------------------------------|
| Identity formation | 3                                |
| Sense of belonging | 3                                |
| Time to completion | 2                                |

Table 1.3: Illustrative examples of the benefits of applying recommendations and the risks of not applying recommendations related to broadening the field's metrics and definitions of student success

|                                                                                                                                                                                 |                                                                                                                                                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Overall BENEFITS of applying recommendations<br>Broader conceptions of success lead to a more diverse, and thus innovative, STEM field.                                         | Overall RISKS of NOT applying recommendations<br>Maintenance of harmful hegemonic framing suppresses diversity and actively harms students and science productivity.                                    |
| Student-level: Centering diverse student values and including students in the processes of research and policy development leads to an increased sense of belonging in science. | Student-level: Mismatches in metrics and definitions of success lead to increased sense of isolation from science for some students.                                                                    |
| Student-level: Student-led policy initiatives lead to more apt educational policy, thus increasing student well-being and attainment of science degrees.                        | Student-level: Ill-fitting educational policy leads to student struggles with mental health (e.g., anxiety and depression) and attrition from science fields.                                           |
| Researcher-level: More nuanced metrics of student success lead to a better ability to predict student attrition, achievement, and other outcome variables.                      | Researcher-level: Current metrics lead to an incomplete ability to make adequate predictions to support students (e.g., how to meet diversity and equity goals, how to foster a competitive workforce). |
| Institutional-level: Broader awareness and critical examination of social hierarchies lays the groundwork for more equitable policies and practices across the institution.     | Institutional-level: Unchecked departmental and institutional biases lead to difficulties attracting and retaining diverse students, staff, and faculty.                                                |
| Society-level: Increased diversity of perspectives in science disciplines allows the field to more readily solve complex problems.                                              | Society-level: Continuation of majority approach to science limits new ideas and perspectives.                                                                                                          |

## **CHAPTER 2 EXPLORING STUDENT PERSPECTIVES: HOW GRADUATE STUDENTS IN A LIFE SCIENCE DEPARTMENT DEFINE SUCCESS**

A version of this chapter was originally published by Maryrose Weatherton and Elisabeth E. Schussler. Vera:

Weatherton, M., & Schussler, E. E. (2022). Exploring Student Perspectives: How Graduate Students in a Life Science Department Define Success. *CBE—Life Sciences Education*, 21(2), ar34.

This article was revised to match the formatting requirements of the University of Tennessee-Knoxville. Maryrose Weatherton was the main author of this article and was involved in all aspects of research ideation, data collection, analysis, and writing. Elisabeth E. Schussler is a coauthor and was involved in research ideation, data analysis, and writing.

## ABSTRACT

Research in science education often has the goal of enhancing student success, yet there is a dearth of literature related to how students define success for themselves. In this study, we explored how 10 life science graduate students defined the term “success,” as well as their experiences related to success. Using interpretive phenomenological analysis, we discovered that students had definitions of success that included multiple components and that students’ definitions varied widely and were influenced by a number of factors. Students described challenges to their success—including lack of departmental support—as well as supports to their success—like caring relationships with others. Students felt guilty about having definitions that were not wholly academic, and their perceived misalignments between these definitions and those of their advisors or department generated negative feelings and a low sense of belonging. Finally, students described how their definitions of success had changed since entering graduate school. Our results suggest that student definitions of success are complex and that, as researchers and programs seek to enhance student success, they should attend to the diverse perspectives that students have about this concept; this may be an integral strategy to address students’ well-being within academia.

## INTRODUCTION

How success is defined within higher education is a complex and important topic. The term “student success” has myriad colloquial and educational meanings; the term can indicate a metric, an independent variable, or a theoretical framework, or it can refer to a process (Weatherton and Schussler, 2021). Given these uses, it is often unclear how the term is defined. Indeed, our previous work revealed that the term “student success” is often invoked within a research context without being explicitly defined (Weatherton and Schussler, 2021). How success is defined is important, because these definitions have cascading impacts on how success is measured, how policy is created, and how students fare within academia. For example, if success is defined solely as an academic construct, then metrics to measure student success may include grade point average (GPA) and standardized test scores. Thus, university admissions policies will likely focus on incoming students’ transcripts and Scholastic Aptitude Test or Graduate Record Examination (GRE) scores, as opposed to a holistic review, impacting students’ outcomes in terms of university admission. Furthermore, the way success is defined may have societal impacts in terms of which students persist within higher education and who then comprises the nation’s future workforce. Thus, these definitions need to be clear and diverse enough to be inclusive of success for all. However, most definitions of success in the literature are outlined by researchers, faculty members, or institutional leaders. Explicitly missing are the voices of students themselves, who are, of course, also experts in student success.

Previous work exploring students’ definitions of ill-defined constructs (e.g., interest, Rowland *et al.*, 2019; failure, Henry *et al.*, 2019) discovered that students have unique points of view, which are not always aligned with the extant literature or institutional practices. We hypothesize that similar misalignments exist between students’ definitions of success and those present within academic and institutional domains (Brauer *et al.*, 2021; Weatherton and Schussler, 2021). If students’ definitions of success are *not* aligned with extant definitions, this may have cascading negative impacts because of the student perception that they do not meet the existing standards for success, and thus do not belong. To explore the impacts of misalignments, we must first examine whether these misalignments exist; while “institutional” definitions of success are relatively easy to glean from extant literature and academic policy, graduate students’ perspectives are explicitly missing from the literature. Indeed, to the best of our knowledge, there has not been an empirical examination of how graduate students define “success.” Thus, the present qualitative study probes how graduate students in one program define success for themselves both within and outside their graduate program. Methodologically, qualitative studies of student views of success offer the needed nuance and richness to construct these complex ideas. Thus, this study used a phenomenological approach to capture the voices of graduate students in a life science program at a research-intensive university in the southeastern United States. Our study had two objectives: 1) Explore how graduate students in a life science program define success. 2) Explore how graduate students describe their experiences related to success.

## ***HOW HAS “SUCCESS” BEEN DEFINED IN THE LITERATURE?***

“Success” has been discussed in education literature for more than 50 years, though it has rarely been explicitly defined (**Carmichael, 1913; Brogden and Taylor, 1950; Tinto, 1975; Baird, 1985**). “Common criteria” measures dominated the nascent field of education research, with reports highlighting the effectiveness of measures like ACT, GRE, and GPA scores to identify successful students (**Robertson and Hall, 1964**). These studies implicitly defined success at all levels of education as high scores on these relatively one-dimensional, quantitative measures. Contemporaries, like **Hartnett and Willingham (1980)**, highlighted the need for more in-depth measures of success, especially at the graduate level; Hartnett and Willingham pointed to issues like the variability of comprehensive exams across disciplines and how factors like GPA struggled to capture the full range of differences in graduate student performance (**Hartnett and Willingham, 1980**). In the 1970s and 1980s, researchers debated various factors that influenced student success and proposed models of student socialization and attrition patterns at universities (**Panos and Astin, 1968; Spady, 1970; Tinto, 1975**). Much of the field’s focus during this time was on student attrition, implicitly defining success as student persistence. Of these studies, only Tinto’s (**1993**) work focused specifically on doctoral students’ departure from graduate programs, indicating that graduate student success was measured by progress through their degree programs.

Success is defined more often in the modern literature, though there is still little consensus on which definitions of success are most useful to capture intended student outcomes. Much of the recent literature that provides a definition for graduate student success focuses on quantitative measures like time to degree and graduation rates (**Gilmore *et al.*, 2016; Zhou and Okahana, 2019; Matheka *et al.*, 2020**). Few studies have incorporated qualitative metrics like subjective well-being into their measures of success (**Castro *et al.*, 2011; Fisher *et al.*, 2019**). **Fisher *et al.* (2019)** measured both publication rate and subjective well-being to interpret pathways to student success for underrepresented science, technology, engineering, and mathematics (STEM) doctoral students. While the field may be in the process of developing a more nuanced view of success by incorporating both quantitative and qualitative measures and expanding the populations that it studies, it has still overlooked a critical voice in the pursuit of a definition of graduate success: that of graduate students themselves.

## ***HOW DO STUDENTS DEFINE SUCCESS?***

While, to the best of our knowledge, there has not been any empirical work examining graduate students’ definitions of success, previous work in undergraduate populations has found that these students have diverse definitions of success. For example, **O’Shea and Delahunty (2018)** found that first-generation undergraduate students defined success in terms of persistence or “defying the odds” and feeling accomplished. Similarly, **Oh and Kim (2016)** found that students of different cultural backgrounds had divergent definitions of success; for example, Mexican-American students’ definitions included helping those in their communities, and Korean-American students often included making their families proud in their definitions (**Oh and Kim, 2016**). These relatively “nontraditional” definitions of success are not often broadcast by

academic institutions—in terms of the structures that they promote, how success is discussed, or how students are implicitly taught about success. We believe that a lack of representative definitions may lead to a host of issues, including a low sense of belonging and poor mental health for students who hold nontraditional definitions of success (**Weatherton and Schussler, 2021**).

It is likely that graduate and undergraduate students have similar definitions of success, though it is unclear how similar they are, as there is a dearth of literature related to graduate students' perspectives on the topic. Thus, documenting diverse definitions of success in both undergraduate and graduate students will contribute to the gap in the academic literature around success. Furthermore, if these definitions are recognized and broadcast by institutions and leaders in the field, it may also positively impact students' well-being and sense of belonging within academia.

### ***WHAT FACTORS MAY IMPACT GRADUATE STUDENTS' DEFINITIONS OF SUCCESS?***

Graduate students' definitions of success are likely to be as unique as each individual within a study, because they are influenced by many factors, such as future goals, past experiences, self-concept, and peer influence, among others. However, to the best of our knowledge, there is currently no empirical work to support the influence of these factors on students' definitions of success. Here, we will review four factors that have previously been linked to students' outcomes in their graduate programs: students' cultural background and family values, academic socialization and identity formation, the student–advisor relationship, and departmental policies and structures. We review these factors because they have been shown to strongly impact students' well-being, persistence, and overall experience within their graduate programs (e.g., cultural background, **Chapdelaine and Alextich, 2004**; socialization, **Tinto, 1993**; Lovitts, **2002**; student–advisor relationship, **Lovitts, 2002**; **Sverdlik et al., 2018**; departmental policies, **Sverdlik et al., 2018**). We posit that if these factors impact student outcomes broadly, then they may impact students' definitions of success and experiences related to success in their program as well, though this has not been thoroughly studied.

#### *Cultural Background and Family Values.*

Attaining success is a goal that many families try to instill in their children. However, the definition of “success” or “achievement” can vary widely by cultural background or family history; for instance, academic achievement may be seen as a means to future career success or as a means to bring honor to one's family (**Trumbull and Rothstein-Fisch, 2011**). The outcomes of these differences have been examined empirically; for example, **Oh and Kim (2016)** investigated differences in academic goals between Korean-American and Mexican-American undergraduate students and found that cultural norms and familial expectations had a large impact on undergraduate students' definitions of academic success. Korean-American undergraduate students reported higher or more stringent expectations from family than Mexican-American students (**Oh and Kim, 2016**). Structural equation modeling by Scheitle and

colleagues (2021) found that graduate students' perceptions of "family values" were strong mediators of students' career goals, highlighting the importance that student values may have on their career intentions and thus how they define success. Variation in graduate students' family values and cultural backgrounds certainly influences their experiences while in graduate school, such as students' definitions of an ideal mentor (Rose, 2005), the relative importance of academic independence (Swagler and Ellis, 2003), and experiences of bias (Scherr *et al.*, 2020).

### *Socialization and Identity.*

When considering graduate students' definitions of success, academic relationships become especially relevant, as these relationships are one of the vehicles for student socialization. Socialization is the process of learning norms, skills, and values of a particular group or community (such as an academic department). During socialization, students are implicitly taught what is and is not acceptable in terms of work-life balance, values, goals, and future career choices (Lovitts, 2007; Sallee, 2011; Perez *et al.*, 2020). We can imagine, then, that the process of socialization may also work to shape students' definitions of success. At the graduate level, socialization has been hypothesized as an integral step in developing students' academic identities and sense of belonging within a field (Adler and Adler, 2005; Liddell *et al.*, 2014). However, improper socialization can occur when graduate students feel as if they do not "fit the mold" of their programs, and this can lead to negative consequences for students' well-being, self-concept, and intention to persist (Gardner, 2008b; Griffin *et al.*, 2020). Thus, if students have different definitions of success than those conveyed during the process of socialization, they may feel tension between these definitions, and this tension may ultimately lead to negative consequences in terms of students' well-being or persistence.

### *Student-Advisor Relationship.*

The student-advisor relationship has frequently been implicated as the most important predictor of the outcome of a student's graduate experience (Golde, 2005; Zhao *et al.*, 2007). Lovitts (2002) outlined the many outcomes over which an advisor holds influence: formation of a student's academic identity, development of a professional network, and the student's subsequent job prospects. Especially relevant is the advisor's contribution as a mentor; German *et al.* (2019) found that doctoral students who were satisfied with the mentorship they received from their advisors were more likely to be satisfied with their job offers postgraduation. While career satisfaction is merely one way to measure success, this study reveals the integral role advisors play when it comes to influencing student conceptions of success. On the other hand, negative interactions with advisors are prevalent in graduate school and can have detrimental impacts on students' experience and well-being. In a study of graduate students' negative mentoring experiences, Tuma *et al.* (2021) found that nearly half of their participants reported a mismatch with their advisors in terms of work style, values, or career goals and that these misalignments resulted in lower-quality relationships and a more negative graduate school experience. Clearly, as a driver of students' socialization and identity



development, advisors hold sway over the norms and expectations around success that are expressed to students (**Gearity and Mertz, 2012**).

### *Departmental Structures.*

Beyond the interactions that graduate students have with those in their departments, departmental *structures*, like financial resources, graduation requirements, and networking opportunities can also influence student goals and definitions of success. O'Meara and colleagues (**2014**) found that departments had the ability to positively influence student agency by encouraging multiple career paths, providing information and financial support, and offering mentoring and guidance. Furthermore, departments broadcast their values in regard to success through the structures they promote—like program requirements and employee policies. For example, **Bodkin and Fleming (2021)** described the lack of formal “family-friendly” policies (i.e., paid leave, childcare assistance) for graduate students in the United States and hypothesized that these policies, or lack thereof, may contribute to women doctoral students leaving their programs at a higher rate than men. This finding suggests that student definitions of success (i.e., having a family *and* a career, maintaining work–life balance) are likely to be influenced by the policies and resources of their programs as much as by the people within the programs.

## ***STUDY OBJECTIVES***

The present study on definitions of student success is novel, because it gathers graduate students' perspectives and centers their voices in the literature. Furthermore, this study aims to explore how graduate students describe their experiences related to success within graduate school in order to investigate factors that contribute to student well-being and persistence. Therefore, this study had two broad objectives: 1) Explore how graduate students in a life science program define success. 2) Explore how graduate students describe their experiences related to success.

## **METHODS**

### ***METHODOLOGICAL FRAMEWORK***

To explore how graduate students understand and experience the phenomenon of success within their graduate program, we used an interpretive phenomenological approach, guided by **Smith et al. (2009)**. Interpretive phenomenological analysis (IPA) is couched in a constructivist epistemology and, as such, seeks to capture how participants make sense of their worlds. As opposed to pure phenomenology, IPA seeks to understand participants' interpretation of a phenomenon in the context of their political, social, and cultural contexts. Thus, given our research questions, phenomenology and IPA were the most appropriate methodological tools. Before participants were contacted, a detailed research plan was approved by the Institutional Review Board at the University of Tennessee, Knoxville (IRB-20-05870-XP).

### ***PARTICIPANTS***

The most integral criterion for participation in a phenomenological inquiry is that participants must have experience with the phenomenon in question (**Creswell and Creswell, 2017**). Thus, we recruited graduate students who had completed at least 1 year of their program. For this

study, we focused on the experiences of graduate students in a specific life sciences department, as M.W. is a graduate student in the same domain. A critical assumption of phenomenological study is that within interviews and discussions “there is an essence or essences of shared experience” between participants and the researcher (Merriam and Tisdell, 2015, p. 26).

Graduate students in one life science department ( $N = 60$ ; 12% MS and 88% PhD) were recruited in Fall 2020 via an institutional email list to participate in one 40- to 60-minute interview about their definitions of and experiences with success in their graduate program. All individuals who expressed interest and who met the aforementioned criteria were invited to participate. Ten out of 60 graduate students in the department completed interviews. Although master’s degree students were not excluded from our recruitment, only PhD students responded to our requests for interviews. Interviews lasted from 40–120 minutes, with an average length of 50 minutes. The interviewer let participants share their experiences and perspectives for as long as they wanted, resulting in the observed variability in interview lengths.

At the time of their interviews, all participants were pursuing doctoral degrees in the same life science department at the same research-intensive university. Our sample was majority female (60%), domestic students (60%; **Table 2.1**). There was an equal split between white and non-white students; to protect the identities of our participants, race will not be identified further. Fifty percent of our sample identified as first-generation students (i.e., neither of their parents possessed a college degree). Finally, 50% of our participants had passed their qualifying exams at the time of interview, a step typically occurring in the second or third year of the program, and thus were considered PhD candidates. More than half of the participants had a stated future career goal as a research-focused academic (e.g., tenure-track faculty at a research-intensive university). Participants also mentioned several other career goals, including teaching-focused academic positions (e.g., faculty at a primarily undergraduate institution), careers with nongovernmental organizations (NGOs; e.g., the Nature Conservancy), at governmental agencies (e.g., the U.S. Geological Survey, the Department of the Interior), private sector research, K–12 STEM education, and other careers outside science altogether (**Table 2.1**). Note that, because participants often cited multiple career goals, the frequency counts total more than 10.

## **INTERVIEWS**

Interview questions were developed by the researchers to generally probe the research questions. The goal was to provide prompts that allowed participants to share their ideas broadly. When developing interview questions, the researchers had in mind the literature regarding factors that may influence students’ definitions of success (cultural background, family values, socialization, etc.), though a conscious effort was made to create interview questions that were not leading and aimed to capture participants’ individual experiences and perceptions. Interview questions went through several rounds of refinement within the researchers’ lab group and members of the M.W.’s dissertation committee. After this, interview questions were further edited for clarity, construct validity, and reliability based on feedback from pilot interviews, which took place in Summer 2020 and involved several graduate students from the same research-intensive university as the study population.

To support confidentiality, participants were given pseudonyms before interviews took place so that participants' real names were never associated with their data. These participant pseudonyms are used throughout the rest of this paper. The interviews took place from October through December 2020. After reviewing consent documents with participants, semistructured interviews were conducted over Zoom teleconferencing software (2020) at the day and time of a participant's choosing. We note that interviews took place during the global COVID-19 pandemic and, as such, were conducted exclusively over Zoom in order to comply with health guidelines. The semistructured interview questions probed the following topics: participants' definitions of success, why participants decided to pursue a graduate degree, and participants' thoughts on how likely they were to achieve success (**Table 2.2**). Furthermore, participants were asked about what factors influenced their definitions of success. Due to the nature of semistructured interviews, each interview covered the same topics, but based on the participants' answers, follow-up questions allowed each interview to explore slightly different areas within those topics (**Smith et al., 2009; Creswell and Creswell, 2017**). For example, although the researchers did not ask specifically about graduate students' experiences with the coinciding COVID-19 pandemic, approximately half of the participants mentioned the topic. Interviews were audio-recorded using Zoom teleconferencing software (2020) and transcribed by the primary author (M.W.) using Otter transcription software (2021).

## **ANALYSIS**

We used Smith *et al.*'s (2009) IPA methods to analyze our interview data. The general process of IPA entails: 1) reading and rereading transcripts, 2) initial noting, 3) developing emergent themes, 4) searching for connections across emergent themes, and 5) looking for patterns across cases (**Smith et al., 2009**).

Each transcript was analyzed individually before noting any themes that transcended interviews; this is essential to the IPA process and draws on the method's idiographic roots (**Eatough and Smith, 2006; Smith et al., 2009**). Thus, the following process was followed: the transcript was read at least three times by the authors while they separately annotated it to note linguistic and descriptive codes, as well as larger conceptual themes. This was repeated for each transcript, after which emergent themes were developed based on shared participant experiences. Throughout the process, both researchers make a conscious effort to "bracket," or set aside, their preconceptions of student success and the factors that may impact it as well as previous transcripts they had read. More details on bracketing and the inductive coding process in IPA can be found in Smith *et al.*'s guide to IPA (2009).

After reviewing all transcripts independently, both researchers met to discuss their codes and themes and to develop a combined codebook. M.W. then finalized the codebook, which was used to assign codes to all transcripts. E.E.S. then conducted a coding audit by using the final codebook to check the codes assigned to the data. A coding audit helps to develop the coherence and plausibility of the interpretation of the data within an interpretive phenomenological analysis (**Smith et al., 2009**). It is important to note that the process of "auditing" within IPA is different from the more common process of measuring interrater reliability. Auditing only intends to

ensure that the account produced is credible, though it leaves room for the possibility that other, equally valid, interpretations may exist (**Smith *et al.*, 2009**). Given the constructivist epistemology of our chosen method, a coding audit is the most appropriate way to ensure validity. After a coding audit was completed, M.W. and E.E.S. reviewed any disagreements in coding together and came to a final agreement on themes.

After all participants' transcripts had been coded and emergent themes were finalized, M.W. performed member checks. This entailed securely sending participants their transcribed interviews with codes and themes annotated throughout. Participants were asked if the transcripts were accurate and if the researchers' codes and themes captured their experiences with success in the graduate program. Four of the 10 participants responded to researchers' requests for feedback, and none of those participants indicated that they had anything to add or edit in terms of their interview transcripts and researchers' interpretations of their experiences.

### ***VALIDITY***

Many methods traditionally used to evaluate aspects of qualitative work, like its transferability and reliability, aim to ensure a uniformity of results among researchers. However, within IPA and an interpretive philosophical framework generally, a foundational epistemological assumption is that participants' experiences are individually constructed according to their social contexts; therefore, there is no universal truth to report. Thus, conventional methods of validity are not applicable to IPA. Instead, leaders in the field of IPA discuss that rigor and validity are primarily derived from accurately reflecting participants' lived experiences (**Yardley, 2000; Smith *et al.*, 2009; Kirn and Benson, 2018**).

We used Yardley's (2000) principles for assessing qualitative research as a framework for providing validity evidence for the methods of this study. These principles include sensitivity to context, commitment and rigor, coherence, and impact and importance. This study demonstrated sensitivity to context through the recruitment of a purposive sample of participants with personal experience with the phenomenon in question. Furthermore, the researchers tried to minimize power differentials between the interviewer and participants by having a researcher of the same power level (i.e., a fellow graduate student) interview participants, as well as conducting interviews at times and in settings that participants chose. This facilitated participants feeling comfortable to fully express themselves and is an aspect of both sensitivity to context and commitment and rigor (**Walther *et al.*, 2013; Kirn and Benson, 2018**). Rigor was also ensured by a thorough and systematic analysis of the data, using methods like coding audits and clear annotation of participants' transcripts. This study exhibited coherence by logically ordering themes and presenting participants' voices as clearly as possible. **Yardley (2000)** claims that validity via the principles of importance and impact are met when participants felt their voices were adequately represented, which we ensured through the process of member checks.

## RESULTS

### ***RESEARCH QUESTION 1: HOW DO GRADUATE STUDENTS IN A LIFE SCIENCE DEPARTMENT DEFINE SUCCESS?***

Participants defined success in various ways, and these definitions comprised many components—from academic and career success to resilience and having a life aligned with students’ personal values (**Table 2.3 and Figure 2.1**). Many of the components of participants’ definitions of success, while coded separately, were inextricably linked, as Dahlia exemplifies: “I define success as, at least for this program in graduate school, like acquiring the skills that it takes and the resources it takes to have a career that you’re happy with and feel like you have an impact.” This definition of success included the “gaining skills,” “career success,” and “aligned with values” codes. Like Dahlia, all of our participants had definitions of success with multiple components, which accounts for the overlapping frequency counts in **Table 2.3**

The most common components within participants’ definitions of success included success as academic achievement (eight participants), career success (six participants), having a career that was aligned with their values (six participants), and gaining skills (six participants). Academic achievement was coded when students talked about success as it related to aspects of their graduate program, like publishing papers, getting grants, passing courses, and graduating. For example, when discussing her definition of success, Lily said, “I mean, if I can get like a pub[lication] every year, that’s great, you know, so I mean, definitely publications is part of success.”

Academic components of students’ definitions were closely tied to career success, which was coded when participants related success to what happened after their graduate program, such as getting a well-paying job, having career flexibility, or being able to get a postdoc position in an interesting field. When talking about how she defined success at the start of her PhD program, Dahlia had a very career-based definition of success: “So, I think, like, I used to define success successes as you know, basically achieving what it takes to become an R1 researcher.” However, when interviews took place, Dahlia had a career goal of working outside of academia and science altogether.

In addition to academic and career success, students often mentioned that they would feel successful if they were able to move through their graduate program in a way that was aligned with their values. The “aligned with values” code was assigned to any definition of success in which participants mentioned seeking fulfillment, delineated their value systems, or related their success to a value they had mentioned previously in the interview (e.g., helping others, honesty). For example, David’s definition of success included “[finding] emotional and intellectual fulfilment, within a career that also allows me to make money with a product framework that does not require the continual betrayal of self.” David conveyed that he wanted to feel intellectually stimulated by both his graduate program and future career, while simultaneously feeling that he was staying true to himself.

Definitional components coded under “gaining skills” often occurred together with other success components, because students often saw the process of gaining skills (in quantitative analysis, writing, and so on) as necessary to achieve academic or career success. Lily, whose career goal was to get a job in academia, included gaining skills in her definition, as she felt that these skills were required to achieve career success: “If I have the skill set that I can get a job, I feel like I’ll be successful, because if I can’t get a job in academia with a PhD, I’m gonna feel pretty unsuccessful.” This code was employed anytime students mentioned gaining skills, getting better at a certain skill (e.g., data analysis, working cooperatively), increasing their toolset, or any similar statements.

Definitional components mentioned by less than half of the participants were achieving goals, happiness, and resilience. A definition that included “achieving goals” was coded whenever participants explicitly mentioned setting and working toward some goal, as Milo does here: “For me, success is just an achievement of your goal. Even if there are small goal[s], just my plan every day to do everything I planned the day before. [That is] success.” Similar to other codes, students mentioned achieving goals as merely one aspect of their success, and these codes often overlapped with others, as in Scarlet’s definition: “[Success] is both meeting goals, personal goals, professional goals, but it’s also meeting them in a way that fits with your broader value system.” This definition includes both “achieving goals” and “alignment with values” components. The “achieving goals” component was only coded within definitions that *explicitly* discussed meeting goals. If participants mentioned specific goals, such as graduating, or gaining a government career, those would be coded under academic and career success, respectively.

A small group of students ( $N = 3$ ) mentioned that one component of success was achieving personal happiness. The happiness component was coded whenever participants specifically mentioned happiness or being happy, whereas “feeling fulfilled” or “doing what I like,” while similar in sentiment, would have been coded under “aligned with values” and “career success” components, respectively. Students often cited the happiness component in opposition to a previous way of defining success, as Lily did: “Happiness has definitely factored into success as I’ve gone along, because I realized you can make yourself completely miserable and [in my] master’s [program] I definitely struggled with that.” Here, Lily mentions her master’s program, where she felt she did not have a strong work–life balance and prioritized getting her work done over her mental health.

Definitions of success that included a “resilience” component were often mentioned in conversations related to students’ mental health. A definition of success that included resilience was coded anytime students mentioned “resilience” specifically or otherwise mentioned overcoming obstacles or recovering quickly from failure. Phea, after having an especially difficult year in graduate school, cited resilience as the most important component of her definition of success:

*And I think a lot of [what] I realized is that being resilient is pretty critical. I’ve had a couple of personal problems ... the last two years have been more challenging than, you know, compared*

*with the rest of my life. And so, I think that I've seen that people who are able to bounce back and get back on the wagon tend to just be happier. And, you know, forget the outcomes, they just tend to have a better quality of life. And so, I think I want that for myself. Yeah, I realized the importance of resilience as something really integral to success.*

Indeed, in both “happiness” and “resilience” definitional components, students seemed to be prioritizing their own quality of life over outcomes, as Phea indicated.

Overall, the 10 participants had an average of 3.7 components to their definitions of success, with a range between 2 and 5. There was no success component that every participant included in their definition of success (**Figure 2.1**).

### ***FACTORS THAT SHAPED PARTICIPANTS' DEFINITIONS OF SUCCESS***

In response to what shaped their definitions of success, participants mentioned five factors: family and cultural values ( $n = 7$ ), past experiences ( $n = 6$ ), friends or other students ( $n = 5$ ), personal values ( $n = 5$ ), and academic advisors ( $n = 2$ ). Family and cultural values were the most commonly mentioned factors, with family and cultural values being coded anytime a student mentioned formative experiences with their families, cultures, or how they were raised. These values were very important to Hector's definition of success: “I think that [my definition of success] comes from a lot, um, a lot of probably family values. And just a lot of just my upbringing where, you know, my parents always encouraged me, my siblings always encouraged me to make a difference in your community to, you know, to use your gifts to help bring out the best in other people.” Indeed, Hector detailed that his family values influenced his personal values, which drove him toward a career teaching others about biodiversity and the importance of local habitats, thus his motivation for completing his graduate program.

The code “past experiences” was used when participants cited any past experiences that did not fall into the other categories (e.g., a past experience with an advisor would fall under “academic advisor”). Past experiences, like experiences working in their intended career fields, helped students learn what success metrics and definitions were practical, as Lily describes: “Yeah, I think the definition of success comes [from having] ‘real person jobs’ in between my master's and this [my PhD], and just finding out what some of those opportunities were like beforehand, and what could I be sustainably happy with.” These experiences in the “real world” gave students like Lily concrete examples of future career paths that they could use to support their definitions of success.

“Friends or other students” was coded when participants mentioned interactions or conversations with others that influenced how they thought of success. These interactions often drove students to define their own success *in opposition* to how they saw friends or other graduate students defining the term. For example, Heather's definition of success was greatly influenced by her experiences with others in her program: “Moving into graduate school has even more cemented that I'm seeing students that look successful in their academic life but may not be successful in other realms of their life.” Indeed, Heather's definition of success included academic and career components, as well as striving for happiness.

“Personal values” was coded whenever participants mentioned forming their definitions of success in accordance with specific personal values. If participants just mentioned “values” generally as shaping their definition of success, researchers followed up to investigate whether those were personal, family, or cultural values or some combination thereof. Personal values mentioned by participants were often the driving forces behind their careers in academia, participants mentioned curiosity, the need to help others, and striving to solve challenges. For example, Phea mentions that her whole life is motivated by solving problems and helping others, and these motivations naturally impacted her definitions of success: “I think my, both these definitions of success to me are very personal ... they’re what I aspire to, rather than something that I’ve ... that I’ve really just inherited from family or something external. Like, I’m very motivated by solving problems with a connection to causes that I care about. I think that comes from just my own my own motivation.” Participants who mentioned the influence of personal values seemed to be very passionate about their values and were often able to explicitly tie these values to their impact on their definitions of success, career goals, and overall motivations.

Finally, “academic advisor” was coded when students specifically mentioned current or previous academic advisors. Interestingly, both times academic advisors were mentioned as influencing a students’ definition of success, they were academic advisors from students’ undergraduate research experiences. Here, Scarlet describes how her former advisor completely changed the way she saw success: “She [my undergraduate advisor] instilled in me that just because you reach your goals does not make you successful. And that there are so many other ways to find success.” This may suggest that the influence of undergraduate advisors can have persisting impacts throughout graduate school.

## ***RESEARCH QUESTION 2: HOW DO GRADUATE STUDENTS IN A LIFE SCIENCE DEPARTMENT DESCRIBE THEIR EXPERIENCES RELATED TO SUCCESS?***

Participants’ discussions about success were categorized into four overall themes that resonated throughout the interview data set. These findings were less about participant definitions of success and more about things that had happened to them related to success in graduate school. These themes were “challenges to success,” “supports to success,” “conflicting definitions of success,” and “reconsidering success” (Figure 2). Taken together, these themes highlight these graduate students’ journeys as they realized what success meant to them, what they needed to be successful, and how to navigate misalignments between their definitions and those of others in the system. In this section, we discuss each theme and its codes.

### ***THEMES 1 AND 2: CHALLENGES AND SUPPORTS TO STUDENTS’ SUCCESS***

The first two themes we describe are diametrically related: challenges and supports to students’ success. Participants discussed at length the challenges they faced and how those challenges resulted in perceived barriers to success. These may have included everyday issues like trying to get in touch with an advisor, to global issues like the fallout from the COVID-19 pandemic. While no two students expressed the same set of challenges, there were four codes within this theme: “poor mental health,” a “low sense of belonging,” a “lack of support,” and the “COVID-19” pandemic. Fortunately, in addition to these challenges, students cited many factors that



supported their success, well-being, and persistence. These factors were encompassed by four codes: “coping,” “external support,” “other students,” and “advisors.” Each code is described in more detail below.

*Challenge: Poor Mental Health.*

Graduate student mental health has been a topic of concern for many advisors, departments, and institutions across a broad range of academic domains. Students in our study, like Yasmin, mirrored these concerns: “I think that science and academia can bring you to a lot of psychological problems, like anxiety, depression, and I have them all.”

These struggles with mental health often led to downstream challenges with motivation, meeting deadlines, and persistence in their program. “Poor mental health” was coded any time participants talked specifically about their mental health issues, like anxiety and depression, or whenever participants discussed feeling extremely stressed or overwhelmed or indicated that their experiences in their graduate program were distressing. For example, Dahlia discussed how, early in her program, she felt very depressed and trapped, which resulted in a lack of motivation toward her dissertation project and her program generally: “I was, like, very depressed my first semester ... and so I just felt like very trapped. And it was like, every single day, I, like, very seriously contemplated dropping out because, like, I wasn’t getting any grants, and I was very understanding of why I wasn’t getting any grants, because, like, it was a dumb project that I didn’t care about.”

While many students in our study discussed poor mental health, many also recognized that struggling with their mental health was nothing to be ashamed of. Indeed, a common conception among the participants was the idea that “a lot of academics” or “everyone” struggles with similar issues, so students should not feel embarrassed about seeking help. Some students, like Scarlet, even mentioned getting help as a catalyst for examining their definitions of success: “I started doing therapy ... and having that external support [her therapist], having a space to really kind of, like, unpack the reasons behind I was feeling as though my success was only dependent on, you know, how many papers I put out, or my grades and things like that, really helped me better define what success is.” Thus, while most students in our study seemed to cite personal mental health struggles, many of them knew how to get help, and often expressed de-stigmatized conceptions of seeking and growing from professional help.

*Challenge: Lack of Support.*

One challenge to success mentioned by the participants was a perception of a lack of support, either from their advisors specifically or the department generally. For example, Dahlia discussed a lack of support from the department in relation to her intended career goals, which, notably, were to find a career outside academia and science altogether: “I think some of my struggle comes from the fact that I’m trying to follow a fairly nontraditional path. And so, I have like, no clear trajectory in which to benchmark myself against.” Similarly, Heather noted a lack of social support from her department: “The department isn’t great at building that support and that community structure.” These quotes expressed a desire for both defined goals and community as essential to graduate student success.

While this code was also likely impacted by the pandemic, students mentioned a lack of support both before and during the transition to virtual instruction. Dahlia mentioned issues with support both before and during the pandemic: “Support from your advisor is like, so important. And it’s something that is a lot better now, but like, at the beginning [my advisor] and I just like did not know how to communicate at all ... and like, they would never reach out to have meetings, like I would always have to reach out to them and then it would feel like I’m defending my right to be in the program every time I would talk to them.” This quote highlights the link between feeling supported and feeling like one belongs in an academic program. Questioning the support from her advisor also made her question whether she belonged in her PhD program. Later, she mentioned that this changed after some time: “[Now] I realize that, like, [my advisor] just wants me to, like, do what makes me happy. Like, they want me to do something that I like, and will get me to a career that I’m happy with.” After a rocky start, Dahlia and her advisor figured out how to communicate in a way that worked for them, and Dahlia felt more accepted and supported.

*Challenge: Low Sense of Belonging.*

Like Dahlia, many students struggled with feelings of belonging in their program. A few students felt that the relatively narrow focus of each lab in the department made it difficult for them to connect with others about their work, while others felt a lack of diversity in the department made them feel like an outsider. For example, Heather discussed how the topics studied by faculty, while interesting, made it harder for her to connect with peers in the department: “But just like, my focus is very different than a lot of folks [in the department] and so it’s harder to go and engage with like, all of the seminars that talk about plants and soil, which is great for a lot of people, but not necessarily what I want to do. So, yeah ... the department isn’t really great at it [making me feel included].” Some participants focused on a lack of diversity among the faculty. Indeed, one of our participants indicated that the lack of diversity within departmental faculty made her feel as if the program was not “built” for people like her: “Um, but I think a lot of it [feeling a lack of belonging] comes from like, we’re pretty white, straight, cis department all like people who have succeeded in the existing system. And so, it’s not necessarily built for a first-generation queer, female.”

Another factor driving students’ sense of belonging was the alignment of their definitions of success with those of their advisors. Although she had almost completed her program, Yasmin said that she had never shared her personal definition of success with her advisor due to a fear that it would not align with her advisor’s definition and she would be seen as less professional,

*I don’t think we ... I don’t think we talk about [our definitions of success]. Um, I think that most of the people I’ve been with, they don’t have the same definition of success that I do. Everyone that are like PIs or professors, I think they measure success with papers, numbers of papers, grants, and, you know, those kind of things. So, I think that I’m somewhat an exception. Yeah. For me, it’s also a little bit embarrassing. Because I feel like, as a scientist, we should all have that same definition [of success]. But we don’t, and most of scientists think that it’s like, yes, number of publications. [If I shared this definition] like, other scientists might consider me like, maybe not adequate or for the job.*

While Yasmin's reluctance to share her definition with her advisor may seem like an extreme case, many participants in our study shared similar worries about misalignments and seeming unprofessional by having definitions of success that were not "academic enough."

#### *Challenge to Success: COVID-19.*

Interviews took place during the Fall semester of 2020, when participants were dealing with the COVID-19 pandemic, lockdown, and transition to virtual instruction on top of existing stressors and responsibilities. Thus, it was not surprising that COVID-19 surfaced as a major challenge to participants' success and well-being. This code encompassed anytime participants discussed COVID-19 or issues resulting from the pandemic. For example, Phea, an international student, discussed how the global pandemic, political turmoil in the United States, and cancelled plans all had a synergistic effect on her mental health: "But this year has been really difficult. Because I felt like I was doing fairly well, and I was really excited about summer because I had this grant and I recruited some undergrads and got them funding for the summer, I was really, really pumped to get some stuff done this year, and COVID just came like, like a wave and laid those plans to rest a little bit. And so, I needed to refocus and do things that were more attainable and had to change a lot of plans."

Beyond changing plans, COVID-19 also forced many graduate students into isolation. Sense of belonging, social connection, and students' motivations are inextricably linked, and Hector expressed how working during isolation presented a challenge to his success and motivation: "I guess my motivation has probably decreased in general, you know, I find it much harder to get up and go to work in the morning, you know, when I'm gonna be sitting in front of a computer for six or eight hours typing code. I think it has a lot to do with COVID, that we spend so much more time in quarantine and isolation that you kind of, you know, it's like, kind of a downward spiral in a lot of ways." Certainly, this code was unique to the timing of this study and captures a layer of nuance that likely influenced many other factors related to student perceptions of success.

#### *Support: Coping.*

The code "coping" refers to all of the ways that students conceptualized their progress and worked through the challenges within their graduate program. For example, Heather explained that remembering that her work was merely one aspect of her life helped her recover quickly from failure, in an example of an "accommodation" coping strategy: "Being able to compartmentalize [that] my graduate work is not my self-worth, or is not my success, and sort of compartmentalizing ... like, I'm not a failure, just because I failed at this part of grad school, I think really helps." By doing this, Heather chose an adaptive strategy to cope with her graduate school stressors.

Another strategy that students employed was distraction, which could be viewed as a negative strategy, yet seemed to be used in a positive way by these students to establish healthy boundaries around their work-life balance. For example, Hector felt a lot of anxiety related to his research, but used "rewards" like participating in his hobbies in order to get through stressful situations: "That's kind of what I look forward to. Yeah, you know, when I'm leaving the lab, or

when I'm coming home from research, I can say, okay, tomorrow, you know, I get to go work out or tomorrow, I get to go soccer or teach, you know? And it's a huge staple in the PhD pursuit, to have the other things in life that you can really rely on to get you through the research aspect." Although students often listed a number of challenges in their graduate program, adaptive coping strategies helped them to set boundaries, maintain a work-life balance, and feel positive about their progress.

*Support: External Support.*

Students cited extensive support networks to bolster success in their programs. When these support networks included people outside academia (e.g., parents, therapists, partners) these were coded as "external support." These external individuals were often integral for students to get an objective opinion on a situation, see a problem in a different light, or just to hold space for students to *not* think about their graduate work. For example, Dahlia discussed that conversations with her friends and her family helped her to relax and take her mind off her graduate work. Another way that Dahlia's family, specifically her mom, supported her success was by providing a sounding board for her to work through her values and how those interacted with her goals for her PhD: "Talks with my mom have, like, very specifically helped me go through value orienting ... like, explicitly thinking about the outcomes [that I want from my PhD] and why. She [my mom] helps me to figure out how to, like, internally validate and not judge myself based on other people's progress." Thus, Dahlia's family and friends were perceived as supportive because of their objective advice and their being external to her program.

External supports, like family and friends, often provided essential affirmations that buoyed students' spirits, such as Lily's partner, who reminded her that she did not have to be constantly striving for success as long as she was happy: "If you're happy being a big fish in a small pond, that's okay. Like, you don't owe it to anyone but yourself." Reminders like this and other affirmations from external support systems were invaluable to graduate students' mental health and their conceptions of success in their programs.

*Support: Other Students.*

Another aspect of students' support systems were other students in their programs or in similar graduate programs. These students were all figuratively "in the trenches" together, so they could offer valuable advice, share previous experience, and perhaps most importantly relate to issues and complaints that graduate students expressed. Heather found that other students in her program supported her by simply being great friends. These friends helped to create "a better work-life balance and community structure." Scarlet found that having conversations with graduate students outside her department built strong friendships and helped her clarify her definition of success: "Also just becoming closer friends with people in different PhD programs. They talked about ways in which they thought about their own success. So, it wasn't kind of the same thing over and over again, that you oftentimes hear from [my department], so I was able to get perspectives from multiple different people in the program." This suggests that peers in particular help to examine conflicts between departmental and individual definitions of success.

*Support: Advisors.*

Perhaps the most important factor that supported students' success was students' relationships with their advisor. Time and time again, education literature has found that the student–advisor relationship is one of the most important predictors of graduate student persistence and academic success (Sverdlik *et al.*, 2018). In our study, participants discussed myriad ways that their advisors supported them, from using their institutional knowledge and their knowledge of the field and career opportunities, to simply offering emotional support and affirmations. For example, Heather's advisor supported her by “sort of helping me establish a network and helping me shape where I want to go ... just opening doors.” This indicates a potential link between advisors and external support networks.

Students, especially those who are new to academia, rely on their advisors for important systemic socialization. David, a first-generation college student, describes how his advisor shared institutional knowledge with him by explaining how to navigate the university: “‘Here’s how to finagle this system,’ ‘here’s how to exploit this sort of motive bureaucracy.’ ‘Here’s how to b\*\*\*s\*\*\* your way through X or Y.’ ‘Oh, those things are excellent professional assets’ stuff like that.”

Especially for first-generation graduate students, advisors can be essential for learning how academia works. Scarlet, another first-generation college student, also describes receiving similar support from her advisor: “And I think also, one way that he helps with success is because he’s so well connected at this point. And is that at the university and in the field for so long? You know, specifically with administration issues, he knows exactly who to email exactly who to talk to, and how firm to be. And that’s something that I didn’t necessarily know that an advisor would be helpful in.” As Scarlet mentions, the need for this type of institutional support may not be obvious to some students until they recognize the benefits of this type of support.

### ***THEME 3: CONFLICTING DEFINITIONS OF SUCCESS***

The theme of “conflicting definitions of success” came up whenever students described a difference between their definitions of success and those of their academic environment. In this section, we will talk about this theme generally, and then discuss the emotional repercussions of students' perceptions of these conflicts. Such conflicts could come up in conversations with advisors, experiences with other academics, or simply students' perceptions of how success was defined within the department. Hector, who had very negative feelings toward his university and the university system generally, felt that most universities prioritized profits over their students and their students' success,

*I think we're kind of stuck in a system where we don't get to necessarily define success, you know, that, that we're stuck in a bit of a rat race, you know, where success is defined by our advisors or institutions, kind of the academic establishment ... so I think the issues of defining success are far beyond even [my institution], it's this whole interconnected web of all these big schools around the country that have jointly established what they perceive to be success, and then they try to force it on graduate students undergrads to feed them into this pipeline to bring in money to the university. Um, yeah, it's a corrupt system for sure.*

This belief made Hector feel like he was stuck in a system where he had to “crank out six or seven publications, write a bunch of grants, go get a postdoc somewhere, and then you enroll into an R1 institution and do the same thing.” Hector felt that these requirements were in opposition to his desire to become an excellent teacher, engage in community outreach, and foster future researchers. These beliefs, along with frustration about his ability to change the system or be listened to by his advisor or department, resulted in Hector feeling trapped and unable to achieve success.

Milo was similarly frustrated with how he felt success “must” be defined in order to be recruited for a career postgraduation. With the hopes of getting a career in academia after his graduate program, Milo had shifted his definition of success toward one that was more aligned with that of “academia” broadly:

*I see how people value you just because of your papers. And I [was] like “wow, man, I need some good papers.” Having a very good paper and high impact factor [can] just change your life. So, that changed my focus to, for example, prioritize papers compared with other goals ... like, conference[s] or this kind of stuff. Yeah. Because people don’t look at how many conferences you attend[ed]. Were you instructor of record? Okay, you are in grad school, busy at teaching, and then you end up with zero paper[s] and nobody wants to recruit you.*

When asked if these were just the metrics that his field used to measure success, Milo replied that “it’s just everybody in academia” who measured success that way, suggesting that there was no way to get around these definitions.

Beyond frustration, when students felt that they were faced with these conflicts, they also felt distressed or as though they were not cut out for the rigors of academic life. This was especially true when students felt that their definitions of success were misaligned with those of their advisors. This was the case for Lily, who, while not as distressed as other students, felt stressed that her definition of success was not enough compared with how her advisor would define the concept,

*And [my advisor] is constantly going for, like, [governmental agency’s] grants ... all these huge grants, so I’m sure their success would be raking in lots of grants, and then getting lots of publications in high impact journals. Like, I don’t know ... don’t [get] me wrong, I’d love a high-impact journal. But if, you know, if I get an open journal that people can access, and it’s out there, I’m thrilled to death. So, there might be like, differences in like tiers, like, I’m happy to just get it out there. And then they’re wanting me to shoot for up there, which can be stressful.*

Lily’s definition of success mainly focused on her impact on her community: “I feel like having a local impact is super important. Because otherwise, why are we doing it? I mean, don’t get me wrong, it’s important to leave your mark scientifically.” And, although she recognized the importance of academic achievement, she felt as if her standards may not be rigorous enough for her advisor; thus, the pair had never explicitly discussed definitions of success.

Discussions within this theme were often laden with guilt on the students' part, like Lily's belief that she was on a different "tier" than her advisor. These feelings of guilt or shame around students' definitions often led to the idea that the student had to have one "public" definition of success and one "private" definition, where public definitions were often academic and career-based, based on students' perceptions of their fields, while their internal definitions often included more nuance and a focus on well-being or things students enjoyed. For example, Yasmin wanted to have a career that was not only academically rigorous but also included time for her family, though she felt like she could not tell her advisor that: "I am applying for a postdoc, right? And so, my advisor [has been] saying, like, why don't you apply [to] this? Why don't you apply here? I'm thinking inside my head, I'm thinking like, because my husband won't be able to come with me, or things like about family. And I don't say it. It's just immediately you think about like, no, that will make me look weak here." Yasmin worried that any definition of success that was not solely career based might make her "look weak" in the eyes of her advisor or "maybe not adequate for the job" in the eyes of future employers. Thus, Yasmin kept her personal definition of success and her dreams of starting an NGO in her hometown to herself, while she focused on the more common "logical" path of getting a postdoc position.

#### ***THEME 4: RECONSIDERING SUCCESS***

Throughout their interviews, students discussed the process of creating and reshaping their definitions of success—from the factors that influenced their definitions to how their definitions had changed over their graduate programs. For example, Heather, whose definition of success centered on happiness and career success, had to redefine what career success meant to her: "[My definition] shifted [in the] sense of what I want out of a job, and like, I guess better evaluating what it would mean to stay in academia versus industry and how I'm defining my happiness." While her definition of success stayed mostly the same, what she considered to be career success expanded after having positive experiences working in a nonacademic career, and this type of change was coded under "shifting success criteria." Students described two types of changes to their definitions: changes to their *metrics* of success while their definitions stayed the same, coded under "shifting success criteria," and changes in their *definitions* over time, which were coded under "evolving definitions."

##### *Shifting Success Criteria.*

A handful of students felt that the way they defined success was fixed, and instead it was their criteria for success or their metrics of success that shifted throughout their programs. For example, Lily's definition of success included being happy and finding career success, and while that had been true since she was in high school, she described the fluidity of her criteria: "But I feel like I don't know, maybe I have a more concrete view of what success is, but the concrete is kind of like fluid. So as long as I'm, you know, not absolutely hating what I'm doing. And I continue to like, work with animals to some degree. I'm pretty happy."

Oftentimes, these metrics changed as students' situations changed, in terms of changing projects, career paths, or life changes outside their graduate programs. Here, Saul describes how career success will look different at each stage of his career: "So, if I speak about success in my career, maybe after the PhD success would be like having publications and postdoc, et cetera. But

during the PhD, would it be maybe like, meeting new people that are important in their fields, contributing to the area of research, expanding your horizons and publishing, right? I think [it] kind of fluctuates. I think the, the definition is quite the same, but the importance to each item changes through time.” These students thought deeply about metrics and measurements for their success. While students who considered success metrics in this way did not make up the majority of our participants, their mindset is an especially interesting one for future research.

### *Evolving Definitions.*

Within their discussions of success, students often described a transition from an “outward” to an “inward” definition of success as they progressed through their graduate programs. Where initially many students had defined success in comparison to others, over time they shifted toward definitions that focused on internal validation. Here, Yasmin describes this process: “Like, I think at the beginning [success] was just to be a good competitive scientist, student, writer, researcher. But that brings you into the comparison and the competition ... I don’t think you could target success if you’re constantly measuring by comparison. Hmm, you know what I mean? Um, so, at points success in the PhD was just finishing like, yeah, closer to the end line it was just finishing, just like graduating.”

Students in our study discussed the stress that came from the “comparison cycle,” the process of constantly comparing their success with that of other students in their programs or other scientists in their fields. Once they were able to focus on what success meant to them, students were able to have a much more rewarding graduate school experience. For example, after issues with both her advisor and her field season, Dahlia took time to re-evaluate the direction of her program and how she saw success,

*Basically, there was a lot of s\*\*t that went down with my advising situation last spring that coincided with like the complete failure of my field season. Yeah, and I took about like three weeks to have a complete mental breakdown. And then like, evaluate what I actually wanted without like trying to follow what someone else has already done. And basically, you know, took bits and pieces that I enjoyed from these other career paths, and I’m now trying to like, formulate my own ... and it’s brutal, but it’s fun now.*

For participants, reconsiderations of success clearly required deep thought and reflection that ultimately reshaped their thinking about what success looks like in their programs.

## **DISCUSSION**

In this study, we documented life science graduate students’ definitions of the term “success” and described these students’ experiences related to success within their graduate program. We found that these graduate students had multiple, diverse components within their definitions of success that ranged from academic and career-focused aspects to those that centered on personal values like happiness and resilience.

Previous literature strongly linked cultural and familial backgrounds, socialization, relationships with advisors, and departmental structures to graduate students’ well-being and academic



outcomes (Tinto, 1993; Lovitts, 2002; Chapdelaine and Alextich, 2004; Oh and Kim, 2016; Sverdlik *et al.*, 2018). We posited that these factors may also be related to students' definitions of success and their experiences with success in their program. Indeed, participants described that their definitions of success were most often shaped by their past experiences and family values, and that their relationships with their primary advisors were an integral support to their success during graduate school. Our study also revealed the importance of external supports in the form of friends, significant others, and mental health professionals to students' perceptions of success. Finally, our study brought to light students' perceptions of misalignment between their and their advisors' (or department's, or institution's) definitions of success. They clearly articulated an understanding that there was a need to project one set of success definitions while perhaps having a different hidden set, and this had implications for some students in terms of their mental health and sense of belonging. This finding highlights the importance of articulating inclusive definitions of success within academia and providing avenues for future research aimed at diversifying graduate education.

Our data suggest that, while students have their own definitions of success, those definitions are influenced by students' perceptions of how success "should be" defined within a field (i.e., normative definitions of success). Students' perceptions of normative definitions are likely shaped by the process of academic socialization (e.g., through interactions with their advisors, faculty members and others). We hypothesize that, if students perceive that their definitions of success are not the same as how success "should be" defined in a field, then these students may experience a reduced sense of belonging. Furthermore, our results suggest that this misalignment affects a number of other outcomes, such as students' feelings of progress, levels of anxiety, and how students re-evaluate success. We represent these findings in Figure 2.3. In this figure, students' definitions of success are "filtered" through their perceptions of normative definitions of success within their fields, which are impacted by the socialization process. This "filtering" has immediate outcomes, which were experienced by the participants in this study, as well as hypothesized distal effects. These data suggest that widening how success is defined within academia and studying how graduate students perceive and experience the process of socialization may be keys to increasing sense of belonging in graduate programs (Figure 2.3).

Prior research related to student success has mainly focused on understanding and leveraging factors that increase student success within higher education (e.g., Hepworth *et al.*, 2018). However, few studies have centered students' experiences related to success. We have previously suggested that, without the explicit inclusion of student voice, academic institutions are likely to continue to uphold hegemonic norms that perpetuate unequal persistence of students within higher education (Weatherton and Schussler, 2021). Thus, amplifying the voices of graduate students is important to broadening the understanding of the many ways that success can be defined and experienced within STEM higher education.

### ***GRADUATE STUDENTS' MULTIPLE DEFINITIONS OF SUCCESS***

While previous work has investigated undergraduate students' definitions of success (e.g., Oh and Kim, 2016; O'Shea and Delahunty, 2018), to the best of our knowledge, this is the first study to explore graduate students' definitions of success. Every participant in our study had a

multifaceted definition of success. Further, no two students had the same definition of success. Students' definitions included many components; some of these components, like academic success and resilience, are well supported by previous work. For example, work by **O'Shea and Delahunty (2018)** found that first-generation undergraduate students defined success as "getting through the day with a smile on my face," among other sentiments related to grit and resilience. This study provides novel descriptions, however, of some components that students included in their definitions of success, like achieving goals or alignment with personal values. Given this diversity in definitions of success, discussions about student success within STEM higher education needs re-evaluation; as our previous work has found, education researchers oftentimes refer to and measure student success as a monolith (**Weatherton and Schussler, 2021**). But our results suggest that these broad generalizations are inappropriate and fail to capture existing nuance within students' perceptions.

These findings have implications for the metrics graduate programs use to determine graduate students' success. We believe that broadening metrics of success within graduate education (e.g., to include those that measure students' development as educators) will better represent graduate students' unique definitions of success. Furthermore, broader evaluation metrics are more appropriate to exhibit graduate students' growth within the many roles they occupy within a department. One option would be to have many metrics available in a graduate program, permitting the advisor and student to customize the metrics based on the goals of the student; this would provide a more nuanced way to assess progress of students in programs.

Graduate students exist within a unique educational context, wherein they are not only students, but also act as teachers, researchers, employees, and more (**Winstone and Moore, 2017; Reid and Gardner, 2020**). We think that some participants may prioritize different components of their definitions of success for these different roles. For example, when Hector thought about being an educator, he described success as "using your skill set to bring out the best in everyone around you," whereas in his role as a researcher, he described success as "crank out six or seven publications, get a bunch of grants, [and] you go get a postdoc somewhere." This malleability is supported by previous work done on graduate student role identity (e.g., **Jazvac-Martek, 2009; Winstone and Moore, 2017; Reid and Gardner, 2020**), which has posited that graduate students switch between their multiple roles as they work through the process of identity work (i.e., the process of refining their academic identities; **Winstone and Moore, 2017**). Many components make up students' academic identities, including students' perceptions of group membership and social categorization (**Camacho et al., 2021**); we posit that an important, yet relatively unstudied aspect is how students' identities and definitions of success are related to each other.

### ***MISALIGNMENTS AND CONFLICTS WITHIN STUDENTS' DEFINITIONS OF SUCCESS***

Given their multiple roles, developing identities, and complex definitions of success, it is not surprising that graduate students in our study faced conflicts and tension among these many factors. Definitions of success, much like role expectations, can develop during the process of socialization. During this process, students may prioritize certain roles and definitions over

others, based on explicit and implicit feedback from those around them. Previous work has found clear evidence of conflict between graduate students' multiple roles (Fairbrother, 2012), and our results show similar conflict between students' multiple definitions of success. For example, participants felt that one could not be seen as prioritizing both social and academic success. This finding has implications for graduate student persistence, a well-known and extant issue within higher education. Graduate students who perceive conflict among aspects of their definitions of success are likely to feel anxiety in a similar way to those who experience role tension (Winstone and Moore, 2017). Over time, these feelings may act as a "selective pressure" against students with diverse or culturally "other" definitions of success, though this is speculative, and more research is needed in this area.

Beyond the tension that students felt among their own definitions of success, participants also cited tension between how they defined success and how success "should be" defined by scientists in a field. Oftentimes, students described this as feeling that their definitions were "wrong." Weidman and colleagues (2001) discuss that the process of graduate student socialization is driven, in part, by advisors and departmental culture. This is supported by our data, which reveal that students often described feeling that their definitions were "wrong" after interactions with their advisors, a member of the department, or even a departmental policy. For example, Dahlia felt that her definition of success, which included factors like happiness and living a life that was aligned with her values, needed to change for her to be a competitive scientist. Her perception was informed by her department's yearly review, which focused mainly on research productivity and meeting graduate school deadlines; to Dahlia, this was an explicit signal that her definition of success was not correct. Furthermore, students in this study felt strongly influenced by the norms and culture of the department, which they cited as one that was focused on productivity and research over teaching and communication and that set unrealistic standards for graduate student achievement. These implicit norms made participants in this study feel stressed and often had a negative effect on their well-being.

The process of socialization, while integral, often functions to uphold hegemonic power, and thus has important implications for practices and policies in the field of graduate education. Hegemonic power is defined as the power that certain classes in society wield over less powerful classes, often in the form of the manipulation of societal norms, values, and language (i.e., soft power; Gramsci, 1971). In our previous work (Weatherton and Schussler, 2021), we discussed how *implicit* definitions of success are likely to benefit groups that are already in power (i.e., people who are white, male, high socioeconomic status), and how students who do not fit into these categories can often have more diverse definitions of success compared with their colleagues, and thus are more likely to feel "othered" by a narrow definition of success. All of the students in this study had extremely diverse definitions of success, and many of our participants expressed that they did not always feel like they belonged in their department or in their fields. These results support previous work that suggests that misalignments in students' definitions can lead to downstream effects on student well-being (Brauer *et al.*, 2021; Weatherton and Schussler, 2021). Our data suggest that advisors and departments must make an effort to understand not only how they are explicitly defining success to graduate students, but also how their departmental culture implicitly condones certain definitions of

success, and thus may harm student well-being. We acknowledge, however, that more research on how departments and faculty members define success is needed. Overall, our results suggest that broadening the way that success is viewed within higher education (to include multiple, diverse components of success) is not only important for individual graduate students' sense of belonging and well-being, but it may also be integral to address systemic structures that function to suppress diversity within the life sciences domain.

### ***CHANGING DEFINITIONS AND METRICS OVER TIME***

All of the students in our study described some aspect of change in their conceptions of success over time. These changes were in either how students defined success or how students measured success. Only a few students in our study described the latter, where changes occurred in their metrics but not in their definitions. For example, Sal described that at each stage of his career—PhD student, postdoctoral student, professor—his definition of success would stay the same, but the way he measures success would look different. This was conceptually distinct from the idea that definitions themselves changed over time. These results have implications for how advisors discuss goals and success with students, suggesting that students who have unique ways of framing success may need individualized advising, but further research is needed in this area.

When students stated that their definitions of success had changed, the changes often occurred over a relatively long period, for example, over the course of their educational careers. This suggests that students' definitions of success are relatively malleable and that they are influenced by an accumulation of experiences, much like their identities. For example, Scarlet described how her definition of success had evolved from childhood through her undergraduate and graduate experiences, with particular interactions and moments standing out as having a large impact on her definition. These findings are consistent with the work of **Limeri and colleagues (2020)**, which showed that undergraduate students' definitions of intelligence were highly variable and changed over time. This finding has implications for how student success is measured within a research context; our results suggest that success may not be a stable concept and should thus be surveyed accordingly.

For a handful of students, there was a definite moment that forced them to change the way they defined success—these were often moments of perceived failure. For students in high-stakes, competency-based environments (i.e., graduate school), failure often causes stress, anxiety, and other negative mental health effects (**Artino *et al.*, 2012; Pekrun and Perry, 2014**). For example, after struggling to present her work, losing an advisor, and having a difficult field season, Dahlia felt defeated. She “took a week to have a breakdown” but then came back with new goals and a new way to define success. Dahlia's new definition, like those of other participants' definitions post-failure, was more aligned with her values and felt more “doable” to her. This suggests that failure may be an important part of the process of creating goals and defining success for students and highlights points where students' mental health may be especially fragile. Many scientists cite failure as an essential part of the learning process and of scientific discovery (**Firestein, 2015; Simpson and Maltese, 2017; Wylie, 2019**). Although failure may be essential to the learning process, that does not make failure *feel* any better; points of failure during a graduate program may be essential times when support from advisors can

have an outsized impact on student outcomes (**Barnes *et al.*, 2010; Allen *et al.*, 2022**). Many students in our study described their trials through failure, but only some of them were able to look back on the process positively. Those who did often cited a strong support network as well as indicators of a growth mindset. Thus, while it is inconceivable that graduate students will not face failure during their programs, our results suggest that support during graduate school can improve student outcomes and assist students in achieving success.

### ***LIMITATIONS***

Our study has several limitations to consider when interpreting these results. In accordance with our analysis method, we purposefully sampled one domain (life sciences) at one university and tried to limit our sample size to fewer than 20 participants. This was done to capture a specific group's perception of the phenomenon in question—success; indeed, IPA studies often try to limit their samples to between 5 and 15 participants in order to find a relatively homogeneous sample, which allows researchers to more finely examine convergence and divergence in participants' experiences (**Smith *et al.*, 2009**). However, and as our data show, these perceptions are impacted by a number of different factors (e.g., sociocultural background, year in the program); thus, the results from this study do not represent a fully comprehensive list of graduate students' definitions of success or graduate students' viewpoints.

Participation in our study was voluntary and relied on the experiences of graduate students who were currently enrolled in a graduate program. Thus, it is possible that graduate students who left their programs may have different definitions of success or different experiences with success in their programs that were not captured in our study. Furthermore, our sample was made up entirely of students pursuing a PhD degree, and these students were mostly white, female, and domestic. As a result, we caution against the generalizability of our results beyond the specific context of our sample.

Data in this study were collected from October to December 2020, and this aspect of our research design certainly impacted the results. Contextually, there was a global pandemic during our data-collection period, and participants' views may have reflected the anxiety, isolation, and other stressors engendered by this pandemic. For example, isolation during the pandemic may have exacerbated a low sense of belonging, which was a factor present in many of our interviews. We are unable to say how much this context influenced the findings of this study, including those related to students' mental health and their definitions of success.

Finally, our study was limited by our own experiences and biases. We took many steps to address the validity and trustworthiness of our methods (see *Validity*). While we have done our due diligence to explore, understand, and bracket our internal biases as they relate to interpreting data, there will always be limitations inherent to a qualitative study that stem from who is interpreting the data.

### ***RECOMMENDATIONS FOR PRACTICE, POLICY, AND RESEARCH***

This study was exploratory in nature; thus, more research is needed to make any broad claims about graduate students' conceptions of success. However, based on extant literature, we

hypothesize that misalignments between graduate students' definitions of success and their perceptions of normative definitions of success within STEM higher education may have cascading impacts on outcomes such as graduate student persistence, progress toward their degrees, and overall mental health (Figure 2.3). Given our data and these hypothesized impacts, several recommendations are indicated. We have broken our recommendations down by domain: practice, policy, and research.

#### *Recommendations for Practice.*

Our results highlight a number of factors that support student success, including external supports like therapists and coping strategies and engaging in hobbies outside graduate school. As part of the academic socialization process, graduate students should be taught how to use positive coping strategies when they encounter challenges to their success (**Musgrove et al., 2021**).

Given that no two graduate students will likely have the same definition of success, we also recommend that advisors and mentors make space for graduate students to share their unique definitions and experiences. As with reconciling graduate students' multiple roles, we believe that graduate students' multiple definitions of success should be seen as a key strength, not a flaw. This type of "role integration" is likely to have positive cascading impacts on students' productivity, well-being, and ultimately their success within graduate school (**Colbeck, 2008; O'Meara et al., 2017**). Further, given that our results suggest that participants' feelings of misaligned definitions (in relation to their advisors, department, or field) may be negatively correlated with their sense of belonging and well-being, we recommend that those in power share their own definitions of success with students and discuss how these definitions align. Not only will these conversations allow advisors and mentors to better understand their students' goals, but they can also foster strong feelings of support in graduate students. Finally, as recommended by Cooper and colleagues (**2020**) in their study of students with depression, we concur that faculty must normalize failure and assist students in developing a growth mindset.

#### *Recommendations for Policy.*

Results from this study support our previous policy recommendations, such as incorporating broader metrics of success into university evaluation measures and amplifying student voices during the decision-making process (**Weatherton and Schussler, 2021**). Participants in our study cited many factors that supported their success, and university leaders should consult these results as well as the perceptions of students at their universities to decide where to allocate funding and support. However, we recommend that institutions should broaden their definitions of success based on the perceptions of diverse graduate students, thus shifting power from the more "dominant" party within higher education toward those with less power. Furthermore, faculty members must realize the power that they hold in implicitly socializing graduate students and explore their own biases and preconceptions when it comes to how a field should define success.

### *Recommendations for Research.*

Overall, our study indicates that graduate students, as a population, have unique and valuable perspectives. Thus, we recommend that researchers capitalize on this relatively unstudied population and future work should continue to gather graduate students' perceptions. Within this work, researchers should more deeply explore graduate students' perceptions of factors that support their success, as results from these studies can lay the groundwork for practical intervention programs to reduce student attrition. More research is needed to explore how graduate students' definitions of success vary across demographic and contextual factors, as well as across time. Furthermore, to understand how misalignments in definitions of success emerge, we recommend that more research be done to explore how advisors, faculty members, and departments in life science domains define success. Our results suggest that students' concepts of "success" may not be stable across time; thus, we recommend that future research should investigate how these definitions shift across students' academic careers. Furthermore, we encourage researchers to use a wide array of metrics to measure graduate student success and to ensure that their metrics for success align with the perceptions of their study population. Other interesting avenues of exploration include how students' definitions of success are related to their identities and sense of belonging and how these definitions develop as a process of socialization.

## **CONCLUSION**

This study explored life science graduate students' perceptions of success and their experiences with success in their program. We found that graduate students have multiple, diverse definitions of success that are influenced by a wide range of factors. If students felt that their definitions of success were misaligned with their advisors, department, or institution, this often led to intra- and interpersonal tension. Indeed, graduate students in this study often expressed a perception of definitional misalignment in addition to a low sense of belonging within their fields. Overall, the themes discovered in this study suggest that graduate students' definitions of success are shaped over time, both through their experiences and through the process of professional socialization. Furthermore, our themes suggest that graduate students' definitions of success are a unique part of their identities and that these definitions may be tied to graduate students' well-being, perceptions of their program, and future outcomes. To our knowledge, this is the first study that has gathered graduate students' definitions of success and, as such, lays the foundation for future studies that center student voice and address extant issues related to graduate student mental health and persistence within academia.

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## APPENDIX 2

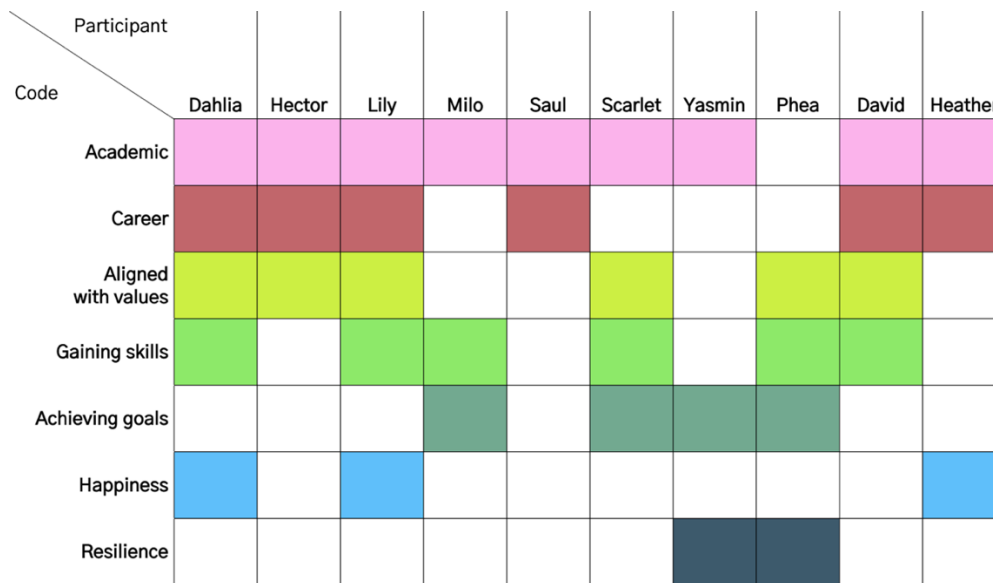


Figure 2.1: Heat map of participants' definitions of success. Participants are listed horizontally across the top of the chart, and components of participants' definitions of success are listed vertically on the left side of the chart.

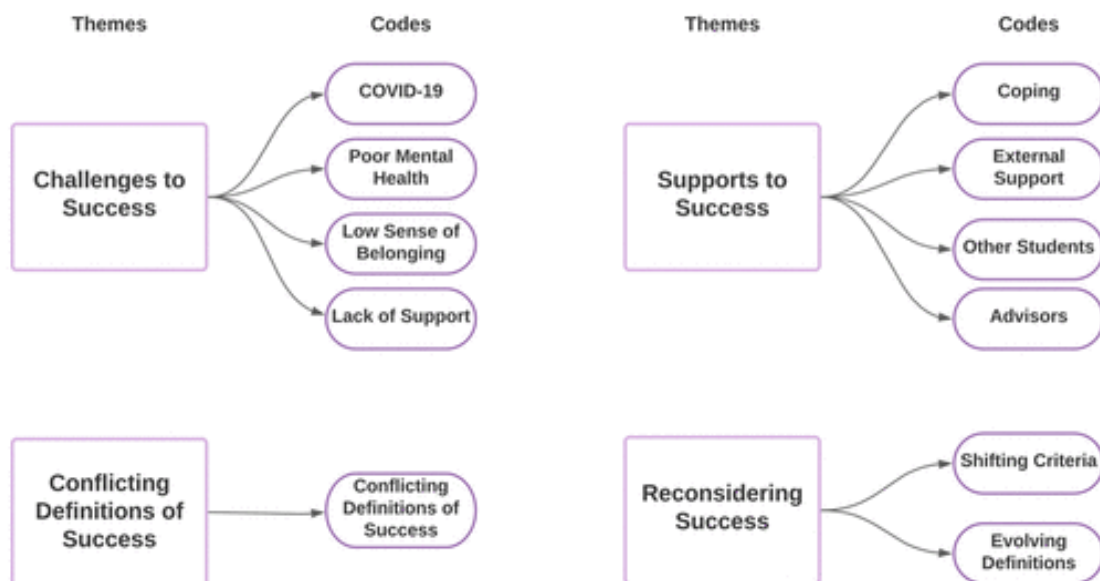


Figure 2.2: Themes and codes present within participants' interviews. Squares represent themes, while ovals represent codes.

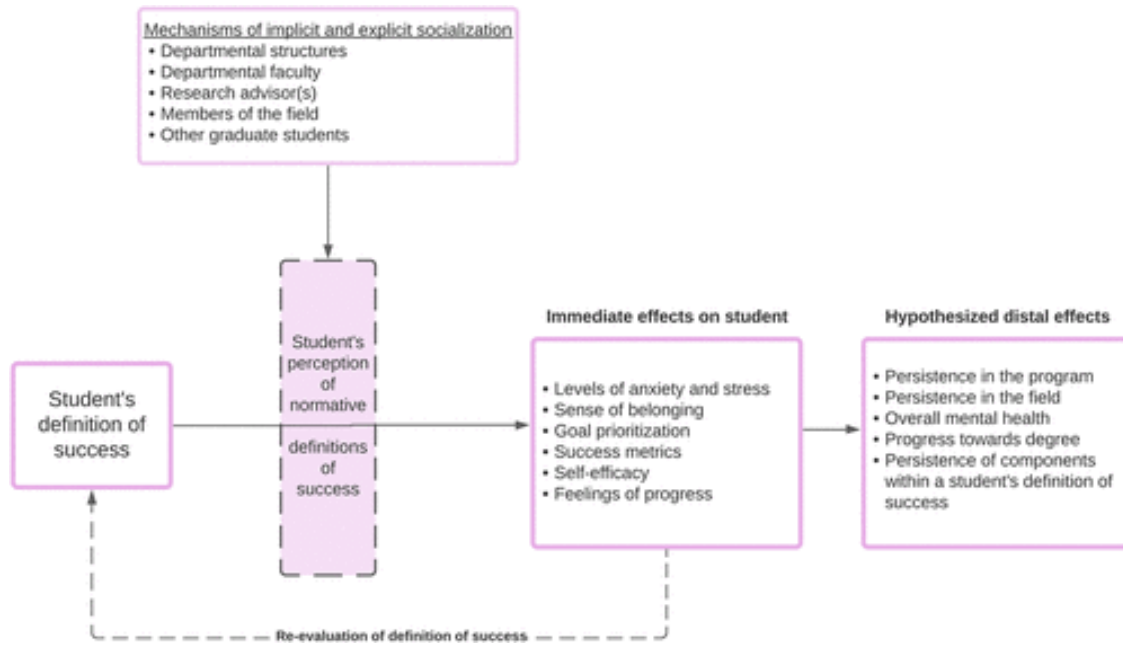


Figure 2.3: Hypothesized interaction between graduate students' definitions of success and normative disciplinary definitions and resulting outcomes. Students' definitions of success are influenced by their perceptions of normative definitions.

Table 2.1: Demographic characteristics of sample population (N=10)

|                                  | <i>Variables</i>                  | <i>Frequency</i> |
|----------------------------------|-----------------------------------|------------------|
| <i>Gender</i>                    | Female                            | 6                |
|                                  | Male                              | 4                |
| <i>Race</i>                      | White                             | 5                |
|                                  | Non-white                         | 5                |
| <i>College generation status</i> | Continuing generation             | 5                |
|                                  | First generation                  | 5                |
| <i>International status</i>      | Domestic                          | 6                |
|                                  | International                     | 4                |
| <i>Candidacy status</i>          | PhD student (pre-qualifying)      | 5                |
|                                  | PhD candidate (post-qualifying)   | 5                |
| <i>Career goals</i>              | Research-focused higher education | 6                |
|                                  | Teaching-focused higher education | 3                |
|                                  | Non-governmental organization     | 2                |
|                                  | Government agency                 | 2                |
|                                  | Private sector research           | 2                |
|                                  | K-12 STEM education               | 1                |
|                                  | Other                             | 1                |

Table 2.2: Interview questions

|   |                                                                                                                                                 |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 | I'm curious to learn from your perspective how you would define success for yourself.                                                           |
| 2 | How would you define success in your program?                                                                                                   |
| 3 | Where did those ideas of success come from?                                                                                                     |
| 4 | Tell me about why you decided to get your PhD.                                                                                                  |
| 5 | On a scale from 1-10, 1 being least likely and 10 being most likely, how likely do you feel like you are to achieve your definition of success? |
| 6 | How have your definitions of success changed since your time as an undergraduate?                                                               |
| 7 | Tell me about a time you felt like you failed during grad school. How did this change how you defined success?                                  |

Table 2.3: Components of participants' definitions of success and the number of participants that identified with that component (N=10)

| Definition                  | <i>Frequency</i> |
|-----------------------------|------------------|
| <b>Academic achievement</b> | 8                |
| <b>Career success</b>       | 6                |
| <b>Aligned with values</b>  | 6                |
| <b>Gaining skills</b>       | 6                |
| <b>Achieving goals</b>      | 4                |
| <b>Happiness</b>            | 3                |
| <b>Resilience</b>           | 3                |

**CHAPTER 3 DEMOGRAPHICS MATTER: NON-WHITE AND WHITE  
LIFE SCIENCE GRADUATE STUDENTS PERCIEVE AND USE  
RESOURCES DIFFERENTLY**



A version of this chapter was originally published by Maryrose Weatherton and Elisabeth E. Schussler. Vera:

Weatherton, M., & Schussler, E. E. (2022). Demographics Matter: Non-white and White Life Science Graduate Students Perceive and Use Resources Differently. *CBE—Life Sciences Education*, 21(4), ar79.

This article was revised to match the formatting requirements of the University of Tennessee-Knoxville. Maryrose Weatherton was the main author of this article and was involved in all aspects of research ideation, data collection, analysis, and writing. Elisabeth E. Schussler is a coauthor and was involved in research ideation and writing.

## ABSTRACT

Many studies and interventions have been conducted to combat differential academic outcomes between majority and minoritized student populations in science, technology, engineering, and mathematics (STEM) higher education; however, few studies have examined resource use as a factor impacting these differences. Resource use is critical to success in myriad fields, and we posit that understanding resource use in graduate education, including the use and perception of resources, may be important in understanding differential outcomes and success among STEM graduate students. We employed a national survey of life science graduate students ( $N = 534$ ) to describe student resource use outcomes and how these outcomes may be related to student demographic characteristics. The survey collected data on the following resource use outcomes: what resources students use, how often they use them, and how useful they perceive them to be. Academic stipend was the most frequently used resource and was perceived to be the most useful resource. Analysis of variance modeling and Tukey post hoc tests indicated that year in program, racial identity, gender identity, and college generation status all impacted student frequency of use or perception of usefulness for some resources, with the greatest differentials between white and non-white students. We conclude with recommendations for policy, practice, and future research.

## INTRODUCTION

Leaders in the fields of science, technology, engineering, and mathematics (STEM) have been advocating for an increase in the racial, ethnic, and gender diversity of individuals holding STEM degrees for more than 30 years (**U.S. Congress, 1991**). Calls for increasing this diversity have been made at every level within higher education—from departments, to universities, to national organizations and agencies (**National Science Foundation [NSF], 2019**). A well-known analogy within STEM fields is that of the “leaky pipeline,” wherein there is a progressive loss from K–12 to higher education of individuals acquiring STEM degrees (Witteveen and Attewell, 2020). These pipeline losses are often members of minoritized populations, including women and people of color (**Kokkelenberg and Sinha, 2010**). The loss of talented individuals from STEM fields is both progressive—in that more individuals leave the field as one progresses from K–12 to postgraduate careers—and persistent—in that this problem has been discussed since the late 20th century but little has changed in terms of outcomes (**Pell, 1996; Chesler *et al.*, 2010; Liu *et al.*, 2019**).

A critical diversity “leak point” in this pipeline occurs at the stage of graduate education. For example, according to the **NSF (2017)**, women of color represented 23.89% of the U.S. STEM graduate student population in 2014; however, during this same time period, women of color represented only 11.96% of the U.S. STEM PhD recipients. Loss of women and students of color from the beginning to the end of the PhD program reduces future scientific capacity for national innovators (**Sowel *et al.*, 2010**) who improve economic, organizational, and national outcomes (**NSF, 2017, 2019**). While the leaky pipeline analogy has been criticized in recent years (e.g., **Cannady *et al.*, 2014**), it is still an important reminder of an extant issue in STEM—the differential attrition of students who are key to a strong scientific future.

Research on the potential drivers of differentials in degree acquisition and persistence between majority and minoritized students in STEM has focused on systemic barriers and biases, which can contribute to a lack of student sense of belonging and feelings of isolation among students less represented in the field. **Liu *et al.* (2019)** detailed several types of barriers to the persistence of women of color within STEM, including implicit bias within academia, barriers to selection and advancement, and the social isolation experienced by many minoritized students. To address these barriers for minoritized students broadly, intervention strategies like mentorship programs (**Dawson *et al.*, 2015**), social support networks (**Schuyler *et al.*, 2021**), targeted hiring (**Sensoy and DiAngelo, 2017**), and implicit bias trainings (**Jackson *et al.*, 2014**) have been well established and empirically tested within the literature, with mixed outcomes. However, one conspicuously understudied factor that could differentially impact student experiences within graduate education is students’ use of resources.

Students seeking a graduate degree likely use myriad resources every day, but very little of this everyday process has been systematically studied within graduate student populations. The use of resources underlies many key aspects of the graduate student experience, including making connections with a dissertation committee, finding appropriate methodological resources, and even having enough institutional support and funding to continue being a graduate student.

Indeed, it is hard to imagine steps of a typical graduate program that do not require resources, suggesting that any barriers to accessing or using resources may be an unexplored factor in degree attainment.

As an example of how a resource may relate to differential outcomes, theories of social capital suggest that first-generation students may be less aware of the academic resources that are available to them, or they may experience barriers to using certain resources (e.g., networking with faculty members; **Gardner and Holley, 2011; Ellis *et al.*, 2019**). This differential resource use compared with continuing-generation students may have cascading effects on academic outcomes (i.e., academic success, degree completion, persistence) and thus may present as differential outcomes between first- and continuing-generation students within STEM programs.

Given the potential importance of resources to graduate student success, and their potential to be related to differential degree outcomes, we implemented a survey to explore the use and perception of resources among life science graduate students. As part of our analyses, we investigated whether the use or perception of resources differed among different demographic groups in order to provide the empirical foundations for future studies of student resource use and student persistence. In the following sections, we will briefly review research that supports the importance of resources as factors related to higher education student outcomes and outline the study's theoretical and methodological frameworks.

## ***RESOURCES AND RESOURCE USE IN HIGHER EDUCATION***

The term “resource” generally refers to an item, person, or place that facilitates an outcome. Oftentimes access *to* or use *of* certain resources is crucial to facilitate a *desirable* outcome, which is why resource use and access has been studied across many fields. These have included studies in economics, where differential resource use is a key factor in neoclassical economic theory (**Goodland and Ledec, 1987**); anthropology, where resource use has been a key factor in the cultural evolution of human civilizations (i.e., the theory of historical particularism; **Bock, 1996**); and ecology, where the totality of resources available in an environment (i.e., the resource landscape) is catalogued to understand which species may persist and which will not (niche theory; **Hutchinson, 1961**). Across many disparate domains of study, understanding fundamental aspects of resource use (e.g., how resources are dispersed in an environment, why individuals choose to use resources, which resources are favored over others) has laid the groundwork for theories that describe more complex interactions. Similarly, we posit that understanding the fundamentals of resource use within graduate education may inform future investigations into differential student outcomes within higher education.

Although resource use has been studied within the education literature for decades, graduate student resource use is not a common focus. As with many other topics within higher education, the majority of published literature concerns populations of undergraduate students. Students' resource use has been studied as a dependent variable, that is, as an outcome of student characteristics or past experiences (K–12 students: **Makara and Karabenick, 2013**); as an independent variable used to predict student academic outcomes or persistence within a course

(undergraduates: **Soria et al., 2013; Stites et al., 2019**); and as a descriptive variable, used by researchers to explain how students in a particular field or class access and use the resources available to them (undergraduates: **Tenopir, 2003; Melvin, 2021**; graduate students: **Furlano et al., 2021**). We provide here a brief summary of research on resource use in higher education, organized by studies of single-resource use and student use of multiple resources.

Studies that examine students' resource use most often frame their research in terms of a single resource, such as student–mentor relationships (undergraduates: **Woods and Preciado, 2016**; graduate students: **Tenenbaum et al., 2001**), graduate students' use of writing communities (**Cahill et al., 2008**), or the use of undergraduate tutoring centers (**Pelleg et al., 2016**). Students' use and perception of a single resource is often studied as an independent variable, with student outcomes as a dependent variable (e.g., academic success, persistence, identity formation). For example, **Hypolite (2022)** investigated the impact of a Black cultural center on the experiences of Black graduate students at a historically white institution. That study revealed that the use of this resource had a number of benefits for Black graduate students, including access to more resources and providing a space for community and support, and highlighted that relatively simple interventions, like the promotion of a single resource, can help address disparate outcomes among graduate students (**Hypolite, 2022**). However, considering the large number of resources students could use and the even larger number of factors that mediate students' use and perception of resources, studies of single resources are inevitably limited (**Makara and Karabenick, 2013**). Thus, studies that examine students' use of multiple resources are needed to more fully describe students' resource use.

Several researchers have examined undergraduate student use of multiple resources or categories of resources (i.e., related groups of resources, like those supporting mental health or all the resources provided in a single class). Studies that examine resource use by category often aim to understand the efficacy of certain programs or factors that drive students to use resources (e.g., undergraduates: **Tenopir, 2003; Melvin, 2021**). For example, **Stites et al. (2019)** measured undergraduate students' use of nine class-provided resources in an introductory engineering class and found nine unique clusters of student resource use patterns; these patterns were mediated by students' frequency of use of each of the class resources. A follow-up study from **Stites and colleagues (2021)** revealed that two of these resource use patterns were significantly predictive of students' content knowledge and course grade. These two studies suggest that students' use of multiple resources may be predictors of student outcomes and thus may be integral to understanding present disparate student outcomes within higher education. However, this work focused on populations of *undergraduate* students. We are mindful that undergraduate and graduate student populations can be quite different from each other (e.g., expectations of independence, diversity in previous experiences and outside commitments; **Lovitts, 2002**) and therefore it may be difficult to apply these findings to a graduate student context with confidence.

Thus, the current literature related to students' resource use exhibits two important gaps: 1) few studies have focused on populations of graduate students, whose context likely makes them

different from undergraduate students in terms of resource use; and 2) studies investigating graduate students have focused on their use of single resources (e.g., advisors, cultural centers) versus investigating the broad landscape of potential resources used by these students. Therefore, we believe that a more comprehensive examination of graduate students' resource use is warranted. Previous research has shown that students' resource choices are motivated by their expectations and values of the resource (e.g., K–12 students: **Eccles and Wigfield, 2002**; undergraduates: **Wirtz et al., 2018**; graduates: **Bloom et al., 2007**), and that student experience and identity can also influence resource use (**Makara and Karabenick, 2013**; **O'Shea and Delahunty, 2018**; **Stites et al., 2019**). Thus, to guide this study, we chose to use **Eccles and Wigfield's (2002)** expectancy-value theory and its subsidiary theory, expectancy-value theory for help sources (EVTHS; **Makara and Karabenick, 2013**), as this study's theoretical and methodological frameworks.

### ***EVT***

This study used Eccles and Wigfield's EVT (**Wigfield and Eccles, 2000**; **Eccles and Wigfield, 2002**) as the theoretical framework driving the study's research objectives and methods and informing the discussion of findings (**Luft et al., 2022**). EVT posits that the learners' contexts and their individual characteristics impact their perceptions and interpretations (of events, themselves, or others), which in turn impact their expectations, values, and ultimately the outcome variable of students' achievement-related choices (i.e., resource use). Figure 3.1 shows a reduced version of the EVT framework with only the variables used in this study. Variables within EVT can be broken down into two categories: proximal and distal variables. Proximal variables include people's expectations for success and task-related values, while distal variables include individuals' cultural milieu, previous experiences, and their goals.

EVT has broad empirical support within education literature; demographic factors like gender (**Watt et al., 2012**) and age (**Jacobs et al., 2002**) as well as the external factor of culture (**Pomerantz and Wang, 2009**) have all been shown to impact students' expectancy beliefs and subjective task values. This is relevant to our study, because EVT predicts that student identities would have a cascading effect on their values and expectations and thus their achievement-related choices (including resource use outcomes). As such, we hypothesized that variables such as students' racial identity, gender, and college generation status represent aspects of their cultural milieu and thus may all impact student resource use outcomes. Similarly, students' years in their programs represent an aspect of their previous achievement-related experiences and thus may similarly impact their resource use outcomes. These hypotheses are supported by previous literature (e.g., **Benenson and Koulkazarian, 2008**; **Ryan et al., 2010**). For example, **Makara and Karabenick (2013)** found that students' resource use was significantly impacted by their gender identity, with women more willing to seek help from "social" resources (e.g., peers and teachers) compared with men. Furthermore, previous work on academic socialization found that, as graduate students advance in their programs, their needs change (e.g., need to secure a sense of belonging vs. a need to secure intellectual mastery; **Golde, 1998**; **Austin, 2002**); thus, we hypothesize that, as students' needs change, so too will the resources they use.

EVT defines expectations as individuals' belief that they can accomplish a task (efficacy expectations) and that a given action will lead to a certain outcome (outcome expectations). Furthermore, the concept of "values" within the EVT model comprises many components: attainment value, intrinsic value, utility value, and cost. Expectations and values directly influence students' choices and outcomes, which are broadly defined within the theory to encompass academic achievement and academic-related choices (**Wigfield and Eccles, 2000**). Many studies have shown support for relationships among expectations, values, and outcomes, including studies of how students' values impact academic achievement (**Eccles *et al.*, 1983**), how expectations of hiring impact job-seeking behavior (**Feather, 1992**), and how expectations of anxiety impact coping strategies (**Pekrun, 1992**). As shown by these examples, EVT's concept of "expectations" and "values" can be broad; thus, we drew on a derivative theory, EVTHS, to serve as our methodological framework to more precisely define our dependent variables for our data collection (**Makara and Karabenick, 2013**).

### ***EVTHS***

**Makara and Karabenick's (2013)** EVTHS was created to understand how types of help sources (e.g., resources like peers, instructors, institutional resources, and nontraditional sources) impact undergraduates' resource use outcomes (i.e., their probability of seeking and using help). While EVT is more useful as a theoretical framework guiding interpretation and implications of our results, EVTHS is far more specific regarding this study's dependent variables—students' resource use outcomes and resource perception. Thus, we used EVTHS as this study's methodological framework. EVTHS includes only three variables, "expectations," "values," and "help-seeking outcomes."

Within its conception of expectations, EVTHS includes students' perceptions of the accessibility or availability of the resource, and the perception that the resource will provide help. These expectations are highly predictive of who or what students turn to for help. For example, **Evenhouse *et al.* (2020)** found that undergraduate engineering students preferred resources that were immediately available, such as online discussion posts, search engines, or class notes. Furthermore, choices between immediately available resources were moderated by students' perceptions of resource relevance; for example, engineering students were inclined to choose search engines to answer problems if discussion posts or class notes did not cover the homework topics (**Evenhouse *et al.*, 2020**). Thus, when choosing between a wide variety of resources to solve a problem, the choice among these resources is affected, in part, by students' expectations about availability and relevance.

The construct of values within EVTHS is composed of students' perceptions of the quality or accuracy of the source along with their perceptions of the alignment in type of help desired and type of help given by a particular resource. In the classroom, value can be conceptualized as how well a resource will meet the needs of the student. For example, undergraduate students who wish to learn a concept (i.e., instrumental help-seeking need) are more likely to ask professors for help as opposed to peers, presumably because professors are likely to provide learning strategies, while peers may simply provide answers; **Karabenick, 2003**). In the context of

graduate school, students' perceptions of resource value and resource quality have broad impacts, from the courses that students choose (e.g., "Do I want an 'easy' course, so I can focus on my research, or do I want a course that will allow me to gain skills for a future career?") to their committee composition (e.g., "Will the advice this faculty member gives me be high quality? Will it be accurate?").

## ***STUDY RATIONALE***

While student resource use may provide key insights into students' academic outcomes, to the best of our knowledge, there is no literature that comprehensively examines how often graduate students use resources within their programs and how useful they find them, and whether resource use is related to graduate student characteristics. Studying the landscape of resource use in graduate school and identifying whether there is evidence of differential resource use among students is a necessary first step to understanding whether resources might differentially impact degree attainment across demographic groups. Thus, using EVT and EVTHS as our theoretical and methodological frameworks, the objectives of this study were to:

1. evaluate life science graduate student resource use outcomes (i.e., overall number of resources used, frequency of use for each resource, and perceptions of usefulness for each resource); and
2. investigate whether graduate student characteristics are related to students' resource use outcomes (i.e., number of resources used, frequency of resource use, and perception of resource usefulness).

Empirical data related to these research objectives can inform university leaders, advisors, and graduate students and will provide evidence for future work on the impacts of resources and differential resource use on graduate students' persistence and academic success.

## **METHODS**

We implemented a survey of life science graduate students within the United States. The decision to restrict participation to just life science graduate students was made because this is the context that the researchers were most familiar with; M.W. is currently a life science graduate student, and E.E.S. is a professor within a life science department. Familiarity with the context of the study participants is important, as it facilitates data interpretation. Before the study began, its design, recruitment, and data analysis methods were approved by the University of Tennessee, Knoxville, Institutional Review Board (IRB no. 20-05870-XP).

## ***SURVEY DEVELOPMENT AND PILOT TESTING***

The survey consisted of 16 questions related to the following topics: students' resource use, students' perceptions of resources, and student demographics (Table 3.1). All sections of the survey, aside from student demographics, were adapted from previous surveys or were created by the authors. The first survey question, which asked students to select all the resources they

used in their programs, was created by the authors. Questions about students' frequency of use and perception of the usefulness of individual resources were adapted from **Wirtz *et al.* (2018)**, with additional support from survey items used in populations of undergraduate students (e.g., **Howley, 2018; Stites *et al.*, 2019**). Demographic questions were adapted from **Fernandez and colleagues (2016)** or from the U.S. Census. All of items were compiled and evaluated by a team of education researchers experienced at developing surveys and studying graduate students (**Schussler *et al.*, 2015; Weatherton and Schussler, 2021**). After developing the survey questions, the authors conducted two rounds of pilot testing from October 2020 through March 2021. The goal of pilot testing is to ensure that survey questions measure the intended construct while minimizing the effect of linguistic, cultural, or individual-level characteristics irrelevant to the study (**American Educational Research Association [AERA], 2014**). The first round of pilot testing was used to establish a list of resources that graduate students used in their programs, as there was no extant list of these resources available at the time of the study. Thus, life science graduate students from one research-intensive institution ( $N = 15$ ) were asked to list all the resources that they used in their graduate program. This list was supplemented by resources found in the graduate education literature base and review by five faculty members. This process resulted in a list of 34 resources that graduate students might use in their programs.

The second round of pilot testing ( $N = 18$ ) asked life science graduate students from multiple universities within the United States to take the full survey and provide feedback about how they interpreted survey questions, any issues they had with the survey, and any resources that they thought were missing from the survey. Goals of this round of pilot testing included establishing the reliability of survey questions (i.e., to ensure the consistency of interpretation across participants; **AERA, 2014; Taherdoost, 2016**), further evaluating the validity of survey questions, and evaluating the validity of the list of resources. The survey and resource list were edited based on participant feedback, after which the full survey was examined by education researchers across multiple domains who evaluated the survey's face and content validity.

## ***SURVEY DESIGN***

Before beginning the survey, participants were presented with IRB-approved consent information and were asked to consent to being a part of the research project. If participants did *not* consent, they were taken to the end of the survey.

Participants were first asked to choose which resources they used in their graduate programs from a provided list of 34 resources. From the list of 34 resources, participants could choose as many resources as they desired to indicate the suite of resources they used in their graduate programs. These selections were carried through to the next two questions, which asked participants how often they used each resource (resource use frequency) and how useful they thought each of the resources were (perception of resource's usefulness).

The choice to collect these variables was informed by our methodological framework, EVTHS. The resource use frequency variable was modeled after the EVTHS outcome variable "help-seeking outcomes." The perception of resource usefulness variable was modeled after two



variables from EVTHS: the *expectation* of “source will provide help” and the *value* of “perceived quality/accuracy of the source.”

To indicate resource use frequency, participants were asked: “Of the resources that you selected in the previous question, please indicate how often you use each resource within your graduate program.” This question was adapted from previous work using EVTHS with undergraduate students (Wirtz *et al.*, 2018; Stites *et al.*, 2019). Responses were set on anchored scales between 1 and 5, where 1 indicated “infrequently” and 5 indicated “frequently.”

Similarly, to measure perceptions of resource usefulness, participants were asked, “Of the resources that you selected in the previous question, please indicate how useful you have found each resource within your graduate program.” This question was adapted from previous work using EVTHS with undergraduate students (Howley, 2018; Wirtz *et al.*, 2018). Responses were set on anchored scales between 1 and 5, where 1 was “not very useful” and 5 was “very useful.”

We collected the following demographic information: current institution, year in program, first-generation status, gender identity, and racial/ethnic identity. Importantly, throughout the article, we refer to first-generation status as defined by students themselves, which may include students who were the first in their families to attend college (i.e., undergraduate institutions) *and* students who were the first in their families to attend graduate school. Our choice to collect these variables was driven by our theoretical framework, EVT, which broadly posits that student characteristics like race and gender identity, as well as previous achievement-related experiences, effect students’ academic choices. Students could skip any questions they felt uncomfortable answering. After completing the survey questions, participants were given the opportunity to enter a drawing for twenty \$20 gift cards.

## **RECRUITMENT**

To recruit the broadest and most demographically diverse sample possible, we used several methods to disseminate the survey and associated materials (introductory email and consent information). IRB-approved recruitment emails were sent to more than 548 program administrators (e.g., departmental administrators, graduate program coordinators, directors of graduate studies) at 120 universities nationwide. These 548 program administrators were purposefully chosen by M.W. to reach a diversity of institution types, including those with student bodies with high demographic diversity. Thus, graduate programs were chosen based on Carnegie classification status, geographic location, and status as minority-serving institutions (including those classified generally as minority-serving institutions, as well as Hispanic-serving institutions, Tribal colleges and universities, and historically Black colleges and universities).

Recruitment emails included a description of the research and participant inclusion criteria, along with a link to the survey and attached consent information. We also sent these materials to several professional society Listservs (e.g., Ecological Society of America, Society for the Advancement of Biology Education Research, National Association for Research in Science Teaching) and posted via social media platforms (e.g., Twitter). The researchers’ goal was for a

sample size of ~160 students, based on previous work that recommended at least 10 participants per survey question to maintain adequate reliability (**Weston and Rosenthal, 2003**).

Inclusion criteria for survey participants included being over 18 years old and currently enrolled in a life science (e.g., zoology, ecology, forestry, horticulture, botany) graduate program in the United States. “Graduate program” could refer to either an MS or PhD program. Each participant’s nationality, race, ethnicity, gender identity, or other characteristics were not specific inclusion or exclusion factors but were self-identified in the survey. The survey was open for 3 months from October to December in 2021.

## ***DATA ANALYSIS***

We received 668 survey responses. This data set was cleaned by taking out partially completed and spam entries (i.e., those defined by the Qualtrics system to have failed a reCAPTCHA test and confirmed by researchers), and those completed by participants in programs outside of the United States). After the data set was cleaned, the total sample size was 534. We conducted data analysis in R statistical software (v. 1.2.5) using the car (**Fox and Weisberg, 2019**), stats (**R Core Team, 2013**), MASS (**Venables and Ripley, 2002**), effectsize (**Ben-Shachar *et al.*, 2020**), ggplot2 (**Wickham, 2016**), and ggpubr (**Kassambara, 2020**) packages.

### ***OBJECTIVE 1: EVALUATE LIFE SCIENCE GRADUATE STUDENTS’ RESOURCE USE OUTCOMES***

We calculated three variables to describe students’ resource use outcomes: 1) the total number of resources used by each student, 2) the relative frequency of use for each resource, and 3) the perception of usefulness for each resource.

The total number of resources used was calculated by simply summing the number of resources each student indicated using. Resource use frequency was calculated for each resource by averaging student responses about how frequently they used that resource. Similarly, the perception of resource usefulness variable was calculated for each resource by averaging students’ answers about how useful they thought each resource was. Both variables only included responses from students who indicated they used a given resource (i.e., response values for participants who did not use a resource were left blank instead of being included as zero values). We chose to use these “relative” values for both frequency and perception of usefulness (as opposed to “absolute” values with zeros included), because the relative values for each resource more accurately represented the perceptions of students who used that resource.

### ***OBJECTIVE 2: INVESTIGATE WHETHER GRADUATE STUDENT CHARACTERISTICS ARE RELATED TO STUDENTS’ RESOURCE USE OUTCOMES***

We analyzed the relationship between several student-level predictor variables (year in program, racial identity, gender identity, and college generation status) and three separate response variables (number of resources used, frequency of resource use, and perception of resource

usefulness). We hypothesized that students' frequency of resource use and perception of usefulness would differ among the different resources; because of this, we ran separate models for each resource (for both frequency of use and perception of usefulness).

We entered each of our predictor variables into R statistical software as factors. We grouped several predictor variables together to ensure adequate statistical power. Statistical power refers to the ability to correctly reject a null hypothesis within any given statistical test, and statistical power is chiefly influenced by sample size (Ellis, 2010). After running a power analysis on our data, we decided to group subcategories of race and year together and to drop two categories of gender identity. Specifically, we grouped racial identities into "white" and "non-white" categories. We grouped 6, 7, and 8+ years in graduate school into one category, called "Sixth+ year." As opposed to combining subcategories, we dropped the gender identity categories of "agender" and "genderqueer" identities from our analysis, as combining these nonbinary gender identities together did not result in statistical power required for analysis. However, descriptive statistics for agender and genderqueer student responses can be found in the Supplemental Material. Our decision to group race/ethnicity categories into white and non-white was based on the NSF's (2019) definition of "minority" populations, which includes "Blacks or African Americans, Hispanics or Latinos, American Indians or Alaska Natives, Native Hawaiians or Other Pacific Islanders, Asians, and persons reporting more than one race." This definition includes all racial/ethnic groups in our data besides white, and grouping race/ethnicity categories by white and non-white provided adequate statistical power. Combining or dropping demographic subcategories is not a preferred practice and represents a limitation in our ability to interpret our data (for further discussion, see *Limitations*). Thus, our data analysis included four factors (i.e., year, race, college generation status and gender), each with different levels (six, two, two, and two, respectively).

#### *Number of Resources Used.*

We used a generalized linear model with a Poisson link function to examine the relationship between the number of resources used (count data) and our predictor variables (i.e., year in program, gender identity, race, and college generation status; Hayat and Higgins, 2014). All predictor variables in this model returned a variance inflation factor (VIF) factor lower than 2, thus we can conclude that there was no multicollinearity present among our predictor variables (Dupuis and Victoria-Feser, 2013).

#### *Frequency of Use and Perception of Usefulness.*

To understand the relationship between student characteristics and how frequently students use resources, we first ran linear models for each resource in our survey that predicted students' rating of their frequency of use by our predictor variables (i.e., year in program, gender identity, race, and college generation status). To ensure that our data were modeled appropriately, we evaluated the normality of model residuals using Q-Q plots (Das and Imon, 2016). Furthermore, we performed two separate tests of normality on each model (Kolmogorov-Smirnov and Shapiro-Wilk; Smirnov, 1948; Shapiro and Wilk, 1965; Das and Imon, 2016). We tested for

possible multicollinearity among the predictor variables in each regression. According to the VIF, variance inflation factor (i.e., VIF; **Dupuis and Victoria-Feser, 2013**), inferences from our models were not affected by multicollinearity of predictor variables. After this, models were adjusted for multiple comparisons using a Benjamini-Hochberg procedure (i.e., false discovery rate adjustment). We chose to use the Benjamini-Hochberg procedure to reduce the number of type 1 errors that may occur when testing multiple hypotheses on a single set of data (**Haynes, 2013; Chen et al., 2017**). After an adjustment for multiple comparisons was made, only models with significance values less than  $\alpha = 0.05$  were further investigated.

Models that were still significant after adjustment were then evaluated by running analysis of variance (ANOVA) models. These ANOVA models were used to calculate the significance and effect size for each predictor variable. Effect size was calculated using Cohen's *F* statistic, which gives the proportion of variance explained by each variable (**Cohen, 1988**). Standard interpretation of Cohen's *F* statistic indicates that values of 0.1, 0.25, and 0.4 represent small, medium, and large effect sizes, respectively (**Cohen, 1988; Chen and Chen, 2010**). After this, models where year in program was a significant predictor were evaluated using a Tukey honest significant difference (HSD) post hoc test. Tukey HSD tests are used to examine pairwise comparisons across multiple factor levels (i.e., Tukey HSD tests were used here to show the difference between first and second years, first and third years, and so on; **Abdi and Williams, 2010**). Tukey HSD tests were only conducted on models for which year was a significant predictor, as all our other predictors only contained two levels (i.e., white and non-white; male and female; and first and continuing generation). This same procedure (i.e., linear modeling, evaluating normality, Benjamini-Hochberg adjustment, ANOVA modeling, Tukey HSD post hoc tests) was followed to model the relationships between student characteristics and students' perceptions of resource usefulness.

### *Resource Categorization.*

To help identify patterns within our data, resources were sorted into broad categories, indicated by an associated color. As we could not find an existing scheme to categorize resources, a team of education researchers, including the authors (M.W. and E.E.S.), created six categories based on how resources are typically used or who provides them. Researchers sorted resources into categories until they came to a consensus. After consensus, researchers created names for the categories. The categories included: academic support, institutionally provided, monetary, networking, and two types of social resources—social resources mainly found within one's degree program ("social-academic") and ones found outside a degree program ("social-nonacademic").

## **RESULTS**

### ***PARTICIPANTS***

**Table 3.2** shows the demographic composition of our sample ( $N = 534$ ). The majority of participants were in the first 3 years of their life science graduate program (64%) and identified as women (70.2%) and white (70.7%). Our sample was about evenly split between participants

who identified as first-generation college students (52.06%) and those who did not (46.4%). Participants who chose to disclose their institutional affiliation (90.8%), represented 80 different universities. We did not ask for department names. Participants mostly attended R1 universities (75.6%), defined as those having very high research activity (**The Carnegie Classification of Institutions of Higher Education, n.d.**). Further, of the universities represented in our sample, 17 were classified as minority-serving institutions (MSI; **U.S. Department of Education, 2020**). Students attending MSIs represented 24.16% of our sample. A map showing the geographic distribution of the universities represented in our sample is shown in Supplemental Figure 1.

### ***OBJECTIVE 1: EVALUATE LIFE SCIENCE GRADUATE STUDENTS' RESOURCE USE OUTCOMES***

#### *Number of Resources Used.*

On average, graduate students reported using 19.42 ( $\pm 0.245$ ) resources from the given list of 34 resources to support their work in their graduate degree programs. The number of resources used by individual participants ranged from one to 33 resources, with a mode of 18 resources. Overall, we found that “advisor” was the resource selected most often by students (selected by 518 of the 534 participants), followed by university courses (491) and online academic journals (486). The three least-chosen resources were international student center, publishing funds, and university career center, selected by only 30, 48, and 53 students, respectively (Table 3).

#### *Frequency of Use and Student Perceptions of Usefulness.*

As noted in the *Methods* section, we show the relative (averages reflect those who selected that resource) versus absolute values for resource use frequency and perception of resource usefulness. Descriptive statistics for each resource in terms of frequency of use and perception of usefulness can be found in the Supplemental Material.

Resources' frequency of use was rated from 1 to 5, with 1 representing infrequent use and 5 representing frequent use. Resource use frequency ranged from a low of 1.89 (university career center) to a high of 4.73 (academic stipend). Of the 34 resources listed in the survey, the most frequently used resource was academic stipend (4.73), followed closely by online academic journals (4.65; Figure 2A).

Similarly, participants evaluated resources in terms of their usefulness, rating resources from 1 to 5, where 1 represented “not very useful,” and 5 represented “very useful.” Average perception of usefulness ranged from 2.93 (university-sponsored events) to 4.85 (academic stipend). Following academic stipend, grants (4.69) and online academic journals (4.67) were the top most useful resources (Figure 2B).

To examine the relationship between students' frequency of use and perceptions of usefulness, we plotted the two variables against each other (i.e., average frequency of use ~ average perception of usefulness; Supplemental Figure 2) and calculated the correlation value between

the two variables. We found that, as predicted by EVT, perceptions of usefulness and frequency of use were positively correlated, with a correlation value of 0.583.

## ***OBJECTIVE 2: INVESTIGATE WHETHER GRADUATE STUDENT CHARACTERISTICS ARE RELATED TO STUDENTS' RESOURCE USE OUTCOMES***

We modeled the interactions between student characteristics (i.e., year in program, race, gender identity, and college generation status) and the three resource use variables (i.e., overall number of resources used, frequency of use for each resource, and perception of usefulness for each resource). We ran one generalized linear model to examine the overall number of resources students used. For frequency of use and perception of usefulness, we ran a separate ANOVA for each resource (thus, 34 models for frequency of use and 34 models for perception of usefulness) and evaluated effect size using Cohen's *F* statistic for each model. In models in which the year in program variable was a significant predictor, we further ran Tukey HSD post hoc tests to evaluate differences among years. We report results from these models in **Tables 4–6**.

### *Number of Resources Used.*

As students' years in their programs increased, so too did the number of resources they used, and these increases across years were highly significant (**Table 4**). Furthermore, our model showed that non-white students used significantly fewer resources than white students and that male students used significantly fewer resources than female students. There were no significant differences between first-generation and continuing-generation students in the number of resources used.

### *Frequency of Use.*

We found 16 resources that differed significantly in terms of students' frequency of use by demographic group. Generally, as year in program increased, students tended to use academic support resources (e.g., departmental faculty, courses) less frequently as compared with previous years (Table 3.5 and Figure 3.3). The only exceptions were that students in year 6 and higher used electronic resources more frequently than in earlier years. Significant models of resource frequency of use by year are shown in Figure 3.3. Thirteen of the 34 resources surveyed were used with significantly different frequencies between white and non-white students; compared with white students, non-white students reported using institutionally provided resources (e.g., university workshops, transit system, health center, career center) significantly more frequently than white students. Furthermore, non-white students used some social-academic resources (i.e., departmental administrators, departmental faculty, special-interest student organizations) significantly more frequently than white students did. These comparisons between white and non-white students are shown in Table 3.5 and in Figure 3.4. Men in our study used grants and mental health counseling significantly less frequently than women did, though they used university gyms more frequently (Table 3.5). The only resource that was used significantly differently between first- and continuing-generation students was university courses, with first-generation students using this resource less frequently than their continuing-generation

counterparts (Table 3.5). Generally, effect sizes for the relationships between student demographics and their frequency of resource use ranged from small to medium, with larger effect sizes for the relationship between year in program and students' frequency of use of university courses (0.6) and the relationships between racial identity and students' use of institutional resources (e.g., university career center, 0.46; university writing center, 0.45).

There were several resources with no significant difference in students' frequency of use across demographic categories. These resources included: academic stipend, advisor, alumni network, conferences, university-provided research facilities, online academic journals, international student center, lab mates, university library, departmental graduate student association, previous mentors, friends, significant others, family, publishing funds, social media, travel funds, and other graduate students. Thus, we can assume that students in our study used these resources with relatively similar frequency, regardless of their demographic characteristics.

### *Perception of Usefulness.*

We found 12 resources that differed significantly in terms of students' perceptions of usefulness by demographic group. Generally, as year in program increased, students tended to perceive some academic support resources (i.e., university courses, departmental faculty) as less useful (Table 3.6 and Figure 3.5). Ten of the 34 resources were perceived significantly differently between white and non-white students in terms of their usefulness. These included some social resources (i.e., departmental faculty and significant others), institutionally provided resources (i.e., university transit, university workshops, university health center), and academic support resources (i.e., university courses), all of which white students perceived as significantly less useful compared with non-white students (Table 3.6 and Figure 3.6). Only one resource, grants, was perceived as significantly more useful by white students compared with non-white students. In terms of gender differences, only one resource, research collaborators, was perceived significantly differently between men and women in our study (Table 3.6). There were no significant differences in perception of resource usefulness between first- and continuing-generation students. Effect sizes for the relationships between student demographics and their perceptions of usefulness were generally smaller than effect sizes seen in the models for students' frequency of use. Effect sizes for models of students' perceptions of usefulness ranged from small to medium, with the largest effect size for the relationship between year in program and students' perceptions of usefulness of departmental faculty (0.23) and special interest student groups (0.31).

There were a number of resources that showed no significant differences in students' perceptions of usefulness across demographic categories. These included: academic stipend, advisor, alumni networks, conferences, university-provided research facilities, online academic journals, international student center, lab mates, university library, university gym, departmental graduate student association, friends, family, publishing funds, social media, travel funds, other graduate students, departmental administrators, university writing center, previous mentors, university career center, and mental health counseling. Thus, we can assume that, regardless of student

demographic characteristics, students perceived the usefulness of these resources relatively similarly.

## DISCUSSION

This study evaluated the many resources that life science graduate students used in their graduate programs and investigated the relationship between student characteristics and student resource use. We found that students used a variety of resources and that students' rankings of their frequency of use and perceptions of usefulness seemed to reflect a hierarchy of needs (**Maslow, 1965**). Specifically, students' most frequently used and useful resources often reflected the fulfillment of basic financial needs (e.g., academic stipend) first, followed by academic and social needs. When investigating the relationship between resource use outcomes and student characteristics, we found that year in program, racial identity, gender identity, and college generation status were all predictors of students' resource expectations and resource use, with racial identity (i.e., white vs. non-white) being a significant predictor for the highest number of resources (14, compared with five for academic year, four for gender, and one for college generation status). Finally, there was a positive correlation between students' perceptions of resource usefulness and frequency of resource use (Supplemental Figure 2) as posited by EVT and EVTHS (i.e., students' expectations and values should be predictive of their resource use outcomes).

Overall, this study supports EVT's theoretical assertion that students' choices (i.e., frequency of use) and their perceptions of value (i.e., perceptions of usefulness) are related and that students' demographic characteristics may impact their resource use choices (Figure 1). The differences between white and non-white student resource use in particular suggests a need to explore whether resources may potentially impact degree outcomes among graduate students. Overall, this study reveals implications for which resources should be emphasized in mentoring conversations, how the academic socialization process may impact student resource use, and which types of resources may matter most to different groups of students.

In previous literature related to graduate studies, the student–advisor relationship is often highlighted as the most important aspect of a graduate program. Previous work has linked the student–advisor relationship to achievement, well-being, and persistence within graduate school (**Liénard et al., 2018; Sheehy, 2019**). Thus, one would imagine that it would be ranked highly in students' perceptions of usefulness and frequency of use. However, while students in our study *did* rank advisor highly, it was not the *most* frequently used resource, nor was it seen as the *most* useful resource. Instead, advisor was the fifth most frequently used resource and the seventh most useful resource, while resources like academic stipend, significant other, and online academic journals were all ranked higher than advisor in both categories. Thus, while our results do support previous work indicating the importance of the student–advisor relationship, our data indicate that students do not perceive advisors to be the *most* important resource within their graduate programs. We suggest that previous results indicating the importance of advisors may have excluded other important drivers of student achievement and persistence by focusing on one resource versus a suite of options.



When provided a broad range of resources, participants in our study seemed to rank them in terms of their ability to fill students' basic needs, like physiological, safety, and social needs (Zivin *et al.*, 2009; Tight, 2020; Bond *et al.*, 2020; Calitz *et al.*, 2020). For example, academic stipend fulfills students' basic physiological needs (i.e., by paying for housing, food, utilities), while dissertation-specific tools like online academic journals, electronic resources, and grants help to ensure students' continuation in their programs, and thus may be considered to fulfill academic safety needs. Beyond these categories, social resources (e.g., family, friends, significant others, lab mates) ranked relatively high in terms of frequency of use and perception of usefulness and indicate the importance of social support to graduate students' success, especially for minoritized students (e.g., Burt *et al.*, 2019; Estrada *et al.*, 2019; Mishra, 2020). The prioritization of resources in this study mirrors theoretical conclusions from Maslow's motivation model (i.e., Maslow's hierarchy of needs), suggesting that this model may be useful in conceptualizing graduate students' resource use in future work (Maslow, 1965).

Our results suggesting the importance of basic physiological, safety, and social needs is a reminder that many graduate students in the United States struggle to meet their basic needs and that this has cascading impacts on performance and success. In the United States, levels of food insecurity among university students (both graduate and undergraduate) are significantly higher than the national average (Bruening *et al.*, 2017; Goldrick-Rab *et al.*, 2018). Furthermore, a 2020 survey found that a quarter of graduate students had experienced housing insecurity in the past year. Further, previous literature has extensively documented that minoritized students (e.g., students of color, first-generation students, low socioeconomic status students) often lack adequate social support and feel stigmatized or otherwise unsafe within higher education (Maffini, 2018; Wilson and Liss, 2020; Livingston, 2021). Naturally, when students' basic needs are unmet, their outcomes suffer; metrics like research productivity, levels of psychological distress, and program attrition have been linked to food and housing insecurity (Millett and Nettles, 2006; Dubick *et al.*, 2016; Nazmi *et al.*, 2019; Balzer Carr and London, 2020), as well as lack of social support (Collie *et al.*, 2017; Li *et al.*, 2018; Mishra, 2020). Despite this, in the United States, the majority of graduate students' stipends are equivalent to or slightly above poverty level (on average, \$35,000 a year; Flaherty, 2018). In addition to a lack of resources to fulfill basic physiological needs, significantly less social support has been reported by international students, when compared with their domestic counterparts, report significantly less social support (Brunsting *et al.*, 2019). Further, Li and colleagues (2021) found that graduate students, regardless of group identity, reported less social and material support during the COVID-19 pandemic. The precarious nature of resources provided to graduate students—just enough stipend to get by, social support predicated on in-person interactions—can cognitively distract students from their academic and career goals. As such, our findings suggest that a need for adequate financial and social support should not be viewed by a department as unnecessary, but instead as critical for student success.

We found that year in program was a significant predictor for all three resource use outcomes: number of resources used, frequency of resource use, and perception of resource usefulness. As student year in program increased, so too did the number of resources that students used, while student frequency of use and perception of usefulness generally showed an inverse relationship

with students' years in their programs. These results support the relationship between previous achievement-related experiences and academic outcomes that is posited by our theoretical framework, EVT (**Eccles and Wigfield, 2002**). **Eccles and Wigfield (2002)** suggest that, as students gain more experience within an academic setting, they tend to change their achievement-related choices. These changes in student choices over time may be further explained by the process of academic socialization, wherein students gain the knowledge, skills, and values needed to succeed within the academic domain (**Tinto, 1993; Weidman et al., 2001**). **Weidman and colleagues (2001)** propose four distinct stages of academic socialization: anticipatory, formal, informal, and personal; each of these stages may see a change in students' resource use outcomes (i.e., the number of resources used, frequency of resource use, and perception of resource usefulness) as well as a change in students' overall knowledge of which resources are available to them. Furthermore, during this process, students generally become more independent and specialized (both in terms of research area and degree-related tasks), and this may explain our findings of an overall decrease in frequency of resource use and perception of resource usefulness as year in program increases (**Lovitts, 2002; Griffin et al., 2020; Weidman, 2020**). Our work suggests that documenting resource use of graduate students over time may be one way to track the progress of socialization or even help to identify students who are having difficulties in their programs. Previous work has found that graduate students undergo a unique socialization process and that interrupting this process can cause student outcomes to suffer (e.g., attrition from program: **Golde 1998**; decreased academic achievement: **Benavides and Keyes, 2016**; decreased sense of belonging: **Strayhorn, 2018**). Thus, the study of expected resource use over time may help to intervene and redirect students toward a more successful path.

Student racial identity was a significant predictor of the frequency of use and perception of usefulness for many resources. These results align with previous work, which has found that non-white students experience graduate programs differently than white students (e.g., **Twale et al., 2016; Guy and Boards, 2019; George Mwangi et al., 2019**). Further, these results support our theoretical framework's proposed relationship between cultural milieu and academic choices, though more data are needed to support a causal relationship between these variables. In our study non-white students often used resources in the institutionally provided and social categories more frequently and perceived them as more useful compared with white students. These results are supported by previous work that has found social support to be integral to the success and retention of non-white students (e.g., Black male graduate students: **Burt et al., 2019**; nontraditional undergraduates: **Cotton et al., 2017**; Native American undergraduates: **Jackson et al., 2003**). Furthermore, previous research has found that institutionally provided resources like university career centers and student cultural centers are helpful for Black and Latino students to find community and discover pathways to success (**Santiago, 2008; Museus et al., 2018; Serrano, 2020**). Despite this empirical support, the past decade has seen large cuts to institutional student services, which serve both graduate and undergraduate students (**Mitchell et al., 2018, 2019; Perry et al., 2020**). Indeed, **Mitchell and colleagues (2019)** revealed that universities in the United States have significantly cut their funding for student services over the past 10 years. However, our results suggest that, while these institutional resources may not be used or perceived equally among all students, they may be

critical for students previously identified to be the most at-risk for attrition. This implies that extant funding structures may be unequally affecting minoritized students. Thus, considering the nuance within students' use and perceptions of resources when creating and enacting policy may be integral to equitable graduate student success.

Student gender identity was a significant predictor for the resource use outcomes for four resources: grants, mental health counseling, research collaborators, and university gym. Based on findings from previous literature and our theoretical framework, we expected to find significant gender differences in resource use for many more resources (e.g., classroom materials, teachers, peers; **Makara and Karabenick, 2013**; **Pramuda et al., 2019**). However, the majority of previous studies examining gender differences in resource use were conducted in primary and secondary school environments, suggesting that more work is needed regarding the relationship between resource use and gender identity within graduate education. In our study, women used more resources overall than men, suggesting that a leaky pipeline of women from graduate programs may not be related to a lack of available resources, but perhaps how those resources are being used. Thus, understanding how women use and perceive resources is one area of future study. Because of sample size constraints, our study was also only able to examine differences between students who identified as men and women, not students with nonbinary gender identities, who are critically understudied. Future work should emphasize a large and diverse sample size to include the experiences of all identities.

Finally, college generation status only predicted the frequency of use and perception of usefulness for one resource: university courses. College generation status *did not* significantly predict the number of resources that students used. These results contradict previous empirical work, which has found that continuing- and first-generation college students experience academia differently. For example, **Engle and Tinto (2008)** found that first-generation undergraduate students were far less likely to seek help from professors than their continuing-generation peers. Much of the scholarship related to first-generation student experiences draws from the theoretical framework of social capital theory, which states that individuals' social networks and knowledge of (mainly white, upperclass) cultural norms are assets that can be leveraged for an advantage within academia (**Bourdieu, 2011**). Thus, one would expect that first- and continuing-generation students would have different resource use outcomes, informed by their differing levels of social capital. However, it may be that the difference in social capital is inconsequential in terms of students' use and perception of resources by the time students reach the level of graduate education. Another possible explanation for our findings may be related to the intersectionality of generation status and other identities (i.e., gender, race, international vs. domestic status), which may be where variation in students' resource use outcomes can be identified.

## ***LIMITATIONS***

We are mindful of several limitations that constrain the conclusions that may be drawn from our results. Specifically, despite our efforts to recruit and collect as diverse a sample as possible, the demographic composition of the sample is not fully representative of the racial, ethnic, and

gender diversity present within life science graduate programs broadly, and the list of resources presented on the survey may not have fully captured all of the resources graduate students use within their programs.

In comparison to overall demographic composition of life science graduate programs in the United States, first-generation students were overrepresented in our sample. The NSF has previously published that ~30% of STEM graduate students are the first in their families to go to college, while they represented the majority (52%) of our sample (NSF, 2015). Within this study, participant demographics within the categories of gender and race and ethnicity are not representative of life science graduate students broadly. Indeed, the NSF determined in 2020 that 60% of life science graduate students were female (compared with 70% of our sample) and that 47% of life science graduate students were white (compared with 71% of our sample; **National Science Board, 2020**). These demographic differences limit the transferability of our findings from the experiences and perceptions of our sample to those of life science graduate students more broadly.

Furthermore, because of the relatively small sample size within certain demographic groups (e.g., mixed-race, Hawaiian or other Pacific Islander) we had to combine multiple demographic categories (i.e., into one non-white category). This limited the conclusions we were able to draw about differences in resource use among non-white graduate students. Previous work has proposed that Asian students are not underrepresented within STEM domains (NSF, 2019; **Chen and Buell, 2018**), and as this study's goal was to understand differences in student resource use that may lead to inequities within higher education, one may conclude that racial groups should have instead been categorized as underrepresented minority (URM) and non-URM groups (i.e., Asian and white students). However, this study used the NSF's definition of "minority" populations (i.e., "Blacks or African Americans, Hispanics or Latinos, American Indians or Alaska Natives, Native Hawaiians or Other Pacific Islanders, Asians, and persons reporting more than one race."), not URMs, to split racial groups. This decision was made because the term "Asian American" represents more than 20 ethnic subgroups (**Hoeffel et al., 2012**), and the assumption that Asian Americans are adequately represented in STEM domains ignores the intragroup diversity in experiences and struggles (**Iporac, 2020; Kang et al., 2021**). Thus, we chose to keep students of Asian racial identity within our categorization of minoritized students, despite the known limitations. We are aware that minoritized students certainly do not experience graduate school as a monolith, and our data are limited insofar as we were unable to examine students' experiences at the appropriate level of detail. Thus, future work should seek a larger and more diverse sample of students in order to tease apart differences in resource use at a more nuanced level.

To account for any resources that were missing from the survey list, participants were given an opportunity to list any other resources they used that did not appear on the list. One hundred thirty-six participants (25%) wrote in additional resources and, of these, participants listed 20 unique resources not included in the survey's resource list. These 20 unique resources were mentioned by 59 participants (10.9% of sample). The other 77 participants wrote in resources that would have been broadly categorized under resources that already existed on the survey list

(e.g., participant listed “journal clubs for credit” when “university courses” was already listed). Given that life experiences, needs, social and academic contexts are unique to each graduate student, it is plausible that some resources may have been missed during survey development, and future research into students’ resource use should incorporate the resources missed in our survey (which we listed in the Supplemental Material) and should have an option for students to write in resources.

## **CONCLUSION**

Our study explored a critically understudied aspect of the graduate school experience: student perception and use of resources. We revealed important descriptive information about life science graduate student resource use and identified relationships between student characteristics like race and year in program and student resource use. Given our results and our intention for these results to inform disparities among students in STEM higher education, we have generated several recommendations for university leaders, advisors, and researchers. First, we suggest that universities and departments focus on policies and support to fill students’ basic needs (e.g., increasing student stipends, ensuring that students feel safe on campus). Once these needs are adequately and equitably addressed, we believe that students will be more able to focus on academic and career success. Furthermore, given that students are *not* a monolith when it comes to resource use, we suggest that universities should survey student resource use and perception before creating resource allocation policies, to most appropriately serve their students’ unique needs. Future research should investigate the factors that drive differences in student resource use and whether these differences in resource use and perception translate into different academic outcomes.

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## APPENDIX 3

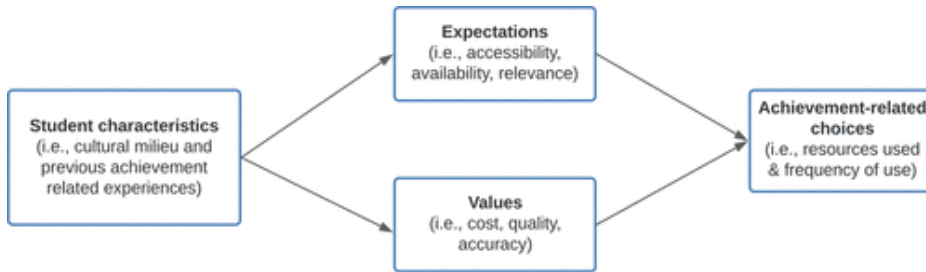


Figure 3.1: Adapted diagram of Eccles and Wigfield's EVT. Boxes indicate variables that influence individuals' choices; arrows indicate direction of influence.

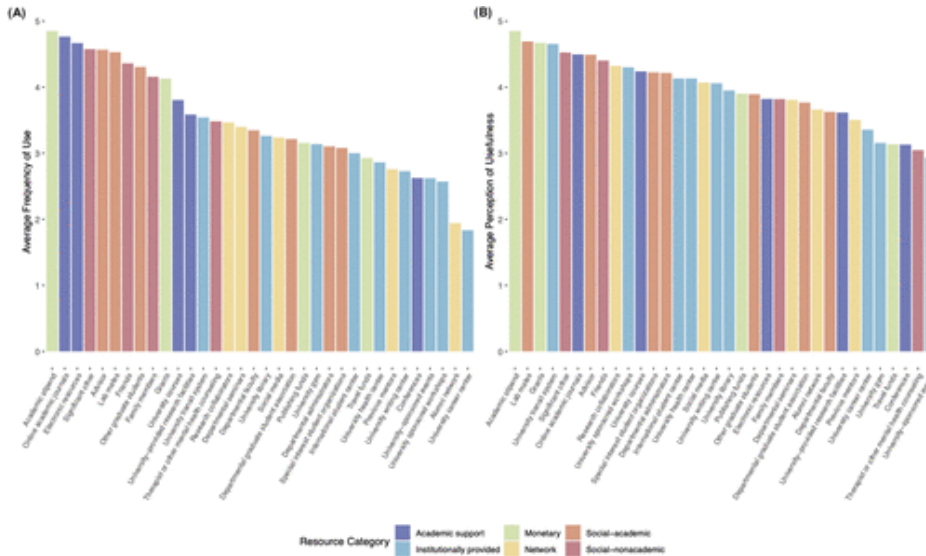


Figure 3.2: Bar chart of 34 resources ranked by (A) average frequency of use and (B) average perception of usefulness. The different colors represent the six broad resource categories: academic support, institutionally provided, monetary, network, social-academic, and social-nonacademic.



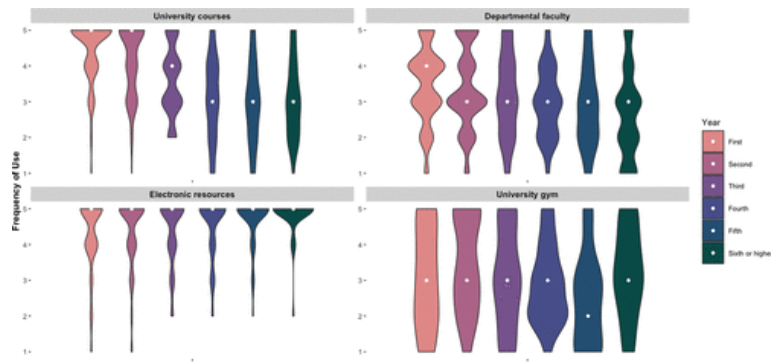


Figure 3.3: Violin plots showing resources for which there were significant differences in frequency of resource use among students based on year in program. White dots indicate median value.

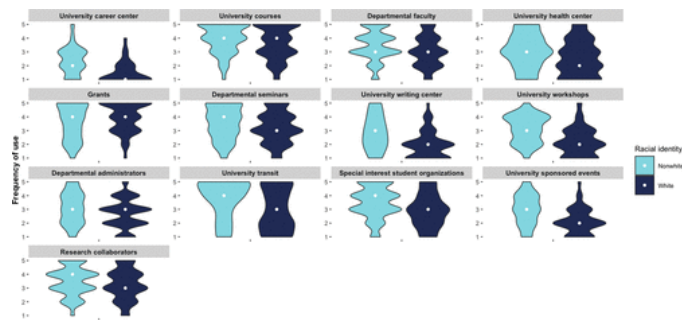


Figure 3.4: Violin plots showing resources for which there were significant differences in frequency of resource use between white and non-white students. White dots indicate median value.

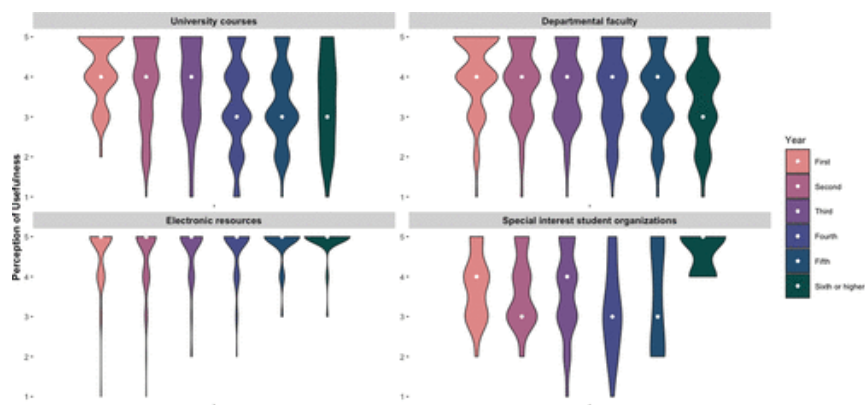


Figure 3.5: Violin plots showing resources for which there were significant differences in perceptions of resource usefulness among students based on their year in program. White dots indicate median value.

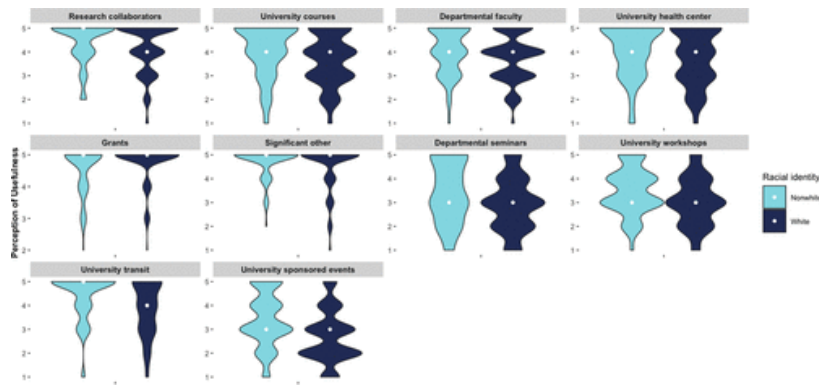


Figure 3.6: Violin plots showing resources for which there were significant differences in perceptions of resource usefulness between white and non-white students. White dots indicate median value.

Table 3.1: Response and predictor variables gathered from survey questions

| Survey question                                                                                                                                                                                                                                       | Variable(s) gathered                                             | Question source                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|--------------------------------------------------------|
| Which of the following resources have you used within your graduate program? These may be resources that you use to collect or analyze data, publish your work, maintain your mental health, sustain a work-life balance, etc. Choose ALL that apply. | Number of resources used                                         | Created by authors<br>Adapted from Mallin et al., 2014 |
|                                                                                                                                                                                                                                                       | Compiled resources used by student                               |                                                        |
| Of the resources that you selected in the previous question, please indicate how often you use each resource within your graduate program.                                                                                                            | Frequency of use (1-5) for each resource used by student         | Wirtz et al., 2018 & Stites et al., 2019               |
| Of the resources that you selected in the previous question, please indicate how useful you have found each resource within your graduate program.                                                                                                    | Perception of usefulness (1-5) for each resource used by student | Adapted from Howley et al., 2015 & Wirtz et al., 2018  |
| Please list the institution that you are currently attending.                                                                                                                                                                                         | Institution type (R1/R2/Other)                                   | Adapted from Fernandez et al., 2016                    |
| What "year" are you in graduate school? (Example: If you arrived this Fall, then you would be "Year 1")                                                                                                                                               | Year in program                                                  | Adapted from Fernandez et al., 2016                    |
| Are you the first person in your family to go to graduate school?                                                                                                                                                                                     | College generation status                                        | Adapted from Fernandez et al., 2016                    |
| How would you describe your gender identity?                                                                                                                                                                                                          | Gender identity                                                  | Adapted from Fernandez et al., 2016                    |
| With which racial/ethnic group(s) do you identify? Choose all that apply                                                                                                                                                                              | Racial identity                                                  | Adapted from US Census Bureau, 2020                    |

Table 3.2: Demographic composition of our sample (N=534)

| Demographic Category                              | Number of students | Percent of total sample |
|---------------------------------------------------|--------------------|-------------------------|
| <b>Race and Ethnicity</b>                         |                    |                         |
| White                                             | 378                | 70.78%                  |
| Black or African American                         | 15                 | 2.80%                   |
| Asian                                             | 44                 | 8.23%                   |
| American Indian or Alaskan Native                 | 0                  | 0%                      |
| Hispanic, Latino, or Spanish origin               | 32                 | 5.99%                   |
| Middle Eastern or North African                   | 5                  | 0.93%                   |
| Native Hawaiian or other Pacific Islander         | 2                  | 0.37%                   |
| Another race or ethnicity not listed              | 8                  | 1.49%                   |
| Multiracial (2 or more races listed above)        | 53                 | 9.92%                   |
| <b>Gender identity</b>                            |                    |                         |
| Man                                               | 133                | 24.90%                  |
| Woman                                             | 375                | 70.22%                  |
| Agender                                           | 4                  | 0.74%                   |
| Genderqueer                                       | 22                 | 4.11%                   |
| <b>First-generation status</b>                    |                    |                         |
| First-generation student                          | 278                | 52.06%                  |
| Not a first-generation student                    | 248                | 46.44%                  |
| Prefer not to answer                              | 8                  | 1.49%                   |
| <b>Year in program</b>                            |                    |                         |
| 1                                                 | 118                | 22.09%                  |
| 2                                                 | 126                | 23.59%                  |
| 3                                                 | 98                 | 18.35%                  |
| 4                                                 | 87                 | 16.29%                  |
| 5                                                 | 61                 | 11.42%                  |
| 6                                                 | 32                 | 5.99%                   |
| 7                                                 | 7                  | 1.31%                   |
| 8+                                                | 5                  | 0.93%                   |
| <b>Institution type (Carnegie Classification)</b> |                    |                         |
| R1                                                | 404                | 75.65%                  |
| R2                                                | 74                 | 13.85%                  |
| Other                                             | 3                  | 0.56%                   |
| No answer                                         | 53                 | 9.92%                   |

Table 3.3: Full list of resources evaluated in this study, number of students who described using each resource, and each resources' average frequency of use (from 1-5) and average perception of usefulness (from 1-5).

| Resource                                  | Resource category    | Number of students using the resource (N=534) | Average frequency of use | Average perception of usefulness |
|-------------------------------------------|----------------------|-----------------------------------------------|--------------------------|----------------------------------|
| Advisor                                   | Social academic      | 518                                           | 4.40                     | 4.49                             |
| University courses                        | Degree tools         | 491                                           | 3.73                     | 3.77                             |
| Online academic journals                  | Degree tools         | 486                                           | 4.65                     | 4.67                             |
| Departmental faculty                      | Social academic      | 480                                           | 3.17                     | 3.81                             |
| Friends                                   | Social non-academic  | 475                                           | 4.14                     | 4.32                             |
| Electronic resources                      | Degree tools         | 470                                           | 4.46                     | 4.66                             |
| Other graduate students                   | Social academic      | 466                                           | 4.03                     | 4.30                             |
| Lab mates                                 | Social academic      | 464                                           | 4.29                     | 4.50                             |
| Academic stipend                          | Monetary             | 462                                           | 4.73                     | 4.85                             |
| Departmental seminars                     | Network              | 395                                           | 3.31                     | 3.05                             |
| Research collaborators                    | Network              | 378                                           | 3.31                     | 4.21                             |
| University library                        | Institution provided | 368                                           | 3.07                     | 3.89                             |
| Conferences                               | Network              | 359                                           | 2.25                     | 3.63                             |
| Family members                            | Social non-academic  | 354                                           | 3.81                     | 4.07                             |
| Significant other                         | Social non-academic  | 347                                           | 4.44                     | 4.52                             |
| Grants                                    | Monetary             | 342                                           | 3.89                     | 4.69                             |
| University health center                  | Institution provided | 331                                           | 2.71                     | 3.82                             |
| University-provided research facilities   | Degree tools         | 316                                           | 3.41                     | 4.41                             |
| Departmental administrators               | Social academic      | 311                                           | 2.81                     | 3.83                             |
| Social media                              | Network              | 277                                           | 3.41                     | 3.14                             |
| Departmental graduate student association | Social academic      | 273                                           | 3.00                     | 3.50                             |
| Previous mentors                          | Network              | 266                                           | 2.72                     | 3.90                             |
| University-sponsored events               | Institution provided | 242                                           | 2.41                     | 2.93                             |

Table 3.4 continued

| Resource                                    | Resource category    | Number of students using the resource (N=534) | Average frequency of use | Average perception of usefulness |
|---------------------------------------------|----------------------|-----------------------------------------------|--------------------------|----------------------------------|
| Therapist or other mental health counseling | Social non-academic  | 241                                           | 3.42                     | 4.24                             |
| University gym                              | Institution provided | 241                                           | 3.01                     | 3.95                             |
| Travel funds                                | Monetary             | 209                                           | 2.40                     | 4.13                             |
| University sponsored workshops              | Institution provided | 198                                           | 2.44                     | 3.15                             |
| University transit system                   | Institution provided | 185                                           | 3.23                     | 4.06                             |
| Special interest student organizations      | Social academic      | 141                                           | 3.13                     | 3.62                             |
| University writing center                   | Institution provided | 81                                            | 2.30                     | 3.36                             |
| Alumni network                              | Network              | 72                                            | 2.00                     | 3.66                             |
| University career center                    | Institution provided | 53                                            | 1.89                     | 3.13                             |
| Publishing funds                            | Monetary             | 48                                            | 2.60                     | 4.21                             |
| International student center                | Institution provided | 30                                            | 2.90                     | 4.13                             |

Table 3.5: Results of a generalized linear model predicting the number of resources students used.

| Predictor variables          | $\beta$ | SE    | <i>P</i> Value             | Reference group      |
|------------------------------|---------|-------|----------------------------|----------------------|
| <b>2<sup>nd</sup> year</b>   | .0871   | .0307 | .0045 **                   | 1 <sup>st</sup> year |
| <b>3<sup>rd</sup> year</b>   | .1895   | .0317 | 2.3x10 <sup>-9</sup> ***   | 1 <sup>st</sup> year |
| <b>4<sup>th</sup> year</b>   | .2334   | .0326 | 7.65x10 <sup>-13</sup> *** | 1 <sup>st</sup> year |
| <b>5<sup>th</sup> year</b>   | .3004   | .0352 | < 2x10 <sup>-16</sup> ***  | 1 <sup>st</sup> year |
| <b>6<sup>th</sup>+ year</b>  | .2610   | .0395 | 4.05x10 <sup>-11</sup> *** | 1 <sup>st</sup> year |
| <b>Nonwhite</b>              | -.0442  | .0193 | .0217 *                    | White                |
| <b>Male</b>                  | -.1567  | .0238 | 4.37x10 <sup>-11</sup> *** | Female               |
| <b>Continuing-generation</b> | .0190   | .0197 | .3346 <sup>NS</sup>        | First-generation     |

In these results,  $\beta$  indicates the difference in number of resources used (log transformed), where positive values indicate more resources used compared to a reference group.

Table 3.6: Compilation of significant outputs from the 34 ANOVA models related to students' frequency of resource use. Tables include ANOVA model p value, effect size (Cohen's F), mean difference values, and Tukey adjusted p values for factors with more than two levels. Resources are color-coded by resource type.

| Demographic group      | Resource             | Directionality of difference | Comparison group     | ANOVA model p value | Cohen's F | Mean difference | Tukey adjusted p value |
|------------------------|----------------------|------------------------------|----------------------|---------------------|-----------|-----------------|------------------------|
| 6 <sup>th</sup> + year | University courses   | Less frequently              | 1 <sup>st</sup> year | <.001               | .60       | -1.40           | <.001                  |
|                        | Departmental faculty | Less frequently              |                      | <.001               | .23       | -0.79           | .002                   |
|                        | Electronic resources | More frequently              |                      | .007                | .19       | 0.51            | .022                   |
|                        | Departmental faculty | Less frequently              |                      | <.001               | .23       | -0.79           | .009                   |
|                        | University courses   | Less frequently              | 2nd year             | <.001               | .60       | -1.10           | <.001                  |
|                        | Electronic resources | More frequently              |                      | .007                | .19       | 0.46            | .049                   |
|                        | Departmental faculty | Less frequently              |                      | <.001               | .23       | -0.59           | .018                   |
| 5th year               | University courses   | Less frequently              | 1st year             | <.001               | .60       | -1.51           | <.001                  |
|                        | University courses   | Less frequently              |                      | <.001               | .60       | -1.23           | <.001                  |
|                        | University gym       | Less frequently              | 2nd year             | .048                | .22       | -1.00           | .018                   |
|                        | University courses   | Less frequently              |                      | <.001               | .60       | -0.63           | .002                   |
|                        | Departmental faculty | Less frequently              | 3rd year             | <.001               | .23       | -0.49           | .041                   |
| 4th year               | University courses   | Less frequently              | 1st year             | <.001               | .60       | -1.39           | <.001                  |
|                        | University courses   | Less frequently              |                      | <.001               | .60       | -1.09           | <.001                  |
|                        | University courses   | Less frequently              | 2nd year             | <.001               | .60       | -0.50           | .011                   |
|                        | University courses   | Less frequently              | 3rd year             | <.001               | .60       | -0.88           | <.001                  |
| 3rd year               | University courses   | Less frequently              | 1st year             | <.001               | .60       | -0.59           | <.001                  |
|                        | University courses   | Less frequently              | 2nd year             | .002                | .15       | -0.31           |                        |

Table 3.5 continued

| Demographic group | Resource                               | Directionality of difference | Comparison group      | ANOVA model p value | Cohen's F | Mean difference | Tukey adjusted p value |
|-------------------|----------------------------------------|------------------------------|-----------------------|---------------------|-----------|-----------------|------------------------|
| White             | University career center               | Less frequently              | Non-white             | .004                | .46       | -0.62           |                        |
|                   | University writing center              | Less frequently              |                       | <.001               | .45       | -0.91           |                        |
|                   | University sponsored workshops         | Less frequently              |                       | <.001               | .42       | -0.92           |                        |
|                   | University health center               | Less frequently              |                       | <.001               | .19       | -0.52           |                        |
|                   | University sponsored events            | Less frequently              |                       | <.001               | .40       | -0.83           |                        |
|                   | University transit                     | Less frequently              |                       | .002                | .24       | -0.70           |                        |
|                   | Grants                                 | More frequently              |                       | .008                | .15       | 0.36            |                        |
|                   | Departmental seminar                   | Less frequently              |                       | .007                | .14       | -0.35           |                        |
|                   | Research collaborators                 | Less frequently              |                       | .049                | .15       | -0.25           |                        |
|                   | Departmental faculty                   | Less frequently              |                       | .001                | .15       | -0.36           |                        |
|                   | Departmental administrators            | Less frequently              |                       | .006                | .16       | -0.37           |                        |
|                   | Special interest student organizations | Less frequently              |                       | .002                | .27       | -0.56           |                        |
|                   | Grants                                 | Less frequently              |                       | .019                | .16       | -0.36           |                        |
| Men               | University gym                         | More frequently              | Women                 | .013                | .20       | 0.45            |                        |
|                   | Therapy                                | Less frequently              |                       | .003                | .23       | -0.76           |                        |
|                   | University courses                     | Less frequently              |                       | .001                | .17       | -0.32           |                        |
| First generation  |                                        |                              | Continuing generation |                     |           |                 |                        |

Note that this table presents the compiled significant results from 34 ANOVA models.

Table 3.7: Compilation of significant outputs from 34 ANOVA models related to students' perception of resource usefulness. Tables include ANOVA model p value, effect size (Cohen's F), mean difference values, and Tukey adjusted p values for factors with more than two levels. Resources are color-coded by resource type.

| Demographic group     | Resource                        | Directionality of difference | Comparison on group  | ANOVA model p value | Cohen's F | Mean difference | Tukey adjusted p value |
|-----------------------|---------------------------------|------------------------------|----------------------|---------------------|-----------|-----------------|------------------------|
| 6 <sup>th+</sup> year | University courses              | Less useful                  | 1 <sup>st</sup> year | <.001               | .10       | -0.84           | <.001                  |
|                       | Departmental faculty            | Less useful                  |                      | <.001               | .23       | -0.72           | <.001                  |
|                       | Electronic resources            | More useful                  | 2 <sup>nd</sup> year | .013                | .18       | 0.39            | .019                   |
|                       | Departmental faculty            | Less useful                  |                      | <.001               | .23       | -0.51           | .043                   |
|                       | Special interest student groups | More useful                  | 4 <sup>th</sup> year | .039                | .31       | 1.41            | .014                   |
| 5 <sup>th</sup> year  | University courses              | Less useful                  | 1 <sup>st</sup> year | <.001               | .10       | -0.86           | <.001                  |
|                       | Departmental faculty            | Less useful                  |                      | <.001               | .23       | -0.56           | .006                   |
|                       | University courses              | Less useful                  | 2 <sup>nd</sup> year | <.001               | .10       | -0.52           | .019                   |
| 4 <sup>th</sup> year  | University courses              | Less useful                  | 1 <sup>st</sup> year | <.001               | .10       | -0.89           | <.001                  |
|                       | University courses              | Less useful                  | 2 <sup>nd</sup> year | <.001               | .10       | -0.55           | .003                   |
| 3 <sup>rd</sup> year  | University courses              | Less useful                  | 1 <sup>st</sup> year | <.001               | .10       | -0.47           | .018                   |
| White                 | University courses              | Less useful                  | Nonwhite             | <.001               | .18       | -0.39           | <.001                  |
|                       | University sponsored workshops  | Less useful                  |                      | .008                | .20       | -0.41           |                        |
|                       | University transit              | Less useful                  |                      | .004                | .22       | -0.47           |                        |
|                       | University sponsored events     | Less useful                  |                      | <.001               | .28       | -0.64           |                        |
|                       | University health center        | Less useful                  |                      | .018                | .13       | -0.32           |                        |



Table 3.6 continued

| Demographic group | Resource               | Directionality of difference | Comparison group | ANOVA model $p$ value | Cohen's $F$ | Mean difference | Tukey adjusted $p$ value |
|-------------------|------------------------|------------------------------|------------------|-----------------------|-------------|-----------------|--------------------------|
| White             | Departmental seminar   | Less useful                  | Nonwhite         | <.001                 | .18         | -0.46           |                          |
|                   | Grants                 | More useful                  |                  | .033                  | .12         | 0.17            |                          |
|                   | Research collaborators | Less useful                  |                  | .015                  | .13         | -0.28           |                          |
|                   | Departmental faculty   | Less useful                  |                  | .002                  | .14         | -0.29           |                          |
|                   | Significant other      | Less useful                  |                  | .032                  | .12         | -0.23           |                          |
| Men               | Research collaborators | More useful                  | Women            | .021                  | .13         | 0.31            |                          |

Note that this table presents the compiled significant results from 34 separate ANOVA models.

**CHAPTER 4**  
**“I DON’T KNOW WHAT I WOULD DO WITHOUT IT” EXAMINING**  
**LIFE SCIENCE STUDENTS’ PERCEPTIONS OF RESOURCE VALUE**

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This article was revised to match the formatting requirements of the University of Tennessee-Knoxville. Maryrose Weatherton was the main author of this article and was involved in all aspects of research ideation, data collection, analysis, and writing. Bailey M. Von der Mehden is a coauthor and was involved in data analysis and writing. Elisabeth E. Schussler is a coauthor and was involved in research ideation and writing.

### **ABSTRACT**

Graduate students often face choices about which resources to use to help them succeed in their programs. These choices likely differ among students, in part, due to different perceptions of resource value. However, little is known about which resources are highly valuable to students, or how perceptions of value inform resource choice. Utilizing Expectancy-Value Theory for Help Sources (EVTHS) as our theoretical framework, this qualitative study explored life science (LS) graduate student high-value resource choices, their explanations about those choices, and how students’ perceptions of resource importance differed among resources and across demographic groups. We addressed two research questions: 1) What resources do LS graduate students consider to be the most important? 2) What drives LS graduate students’ perceptions of resource value? Many participants indicated that ‘advisor’ and ‘academic stipend’ were particularly important. Student perceptions of this value were driven by their perceptions of which needs resources fulfilled. There were few differences in high-value resource choice or value among demographic groups. We propose a model for understanding graduate student resource choice - an academic hierarchy of needs. We believe that this model, along with a further understanding of student resource choice, may inform studies on differential student outcomes.

## INTRODUCTION

Graduate students have access to myriad resources within their programs (e.g., faculty members, university research facilities, online forums) that help them achieve success. A resource can be any item, person, or place that facilitates an outcome, and the use of resources underlies many of the integral moments of graduate study. For example, a student may use an advisor to develop a project, research equipment to collect and analyze data, or presentation software to give a thesis defense. Because students make individual choices about what resources they think they need, each student is likely to use a different set of resources (Weatherton & Schussler, 2022). Differential use of *single* resources, like advisor or family members, can lead to different academic (Gisemba Bagaka's et al., 2015; Sverdlik et al., 2018) and affective outcomes (Blanchard & Haccoun, 2020; Breitenbach et al., 2019). Knowing that overall resource choice varies across students and that differential resource choice leads to differential outcomes in undergraduates (e.g., Stites et al., 2020), it is likely that graduate students' resource choices may be related to variation in outcomes like academic success and programmatic persistence. However, to probe this relationship, we first need to know why students select the resources that they use and the extent to which these resource choices vary among students.

Across domains of study, researchers have been fascinated by the question of what drives individual choice; different theories have posited that aspects of expectations, perceptions, needs, and beliefs all impact decisions (e.g., Expected Utility Theory, Allias & Hagen, 1979; Optimal Foraging Theory, Pyke, 1984; Prospect Theory, Mercer, 2005). This study draws on one of these theories, the Expectancy-Value Theory for Help Sources (EVTHS). EVTHS is an adaptation of Expectancy-Value Theory and was created specifically to explain why students utilize help sources (e.g., resources) (Makara & Karabenick, 2013), making it well-suited as a framework for research on students' perception of resources. EVTHS posits that students' choice of resources is impacted by their perceptions related to each resource; these perceptions can be broken into two categories: expectations and values. For example, as students see a resource more favorably (i.e., students viewing a resource as higher quality (value), or more accessible (expectation)), they're more likely to choose to use that resource (Makara & Karabenick, 2013). Previous research in undergraduate populations supports this relationship (e.g., Mecee, Wigfield, & Eccles, 1990; Scoulas & De Groote, 2022; Yu, Trei & Carlstone, 2018). However, few studies have utilized EVTHS to explore graduate students' perceptions of resources. This study sought to examine one factor driving graduate students' resource choice, their perception of resource value. As posited by EVTHS, we hypothesized that students are more likely to choose resources perceived to be higher in value, and thus, individual differences in student perceptions of resource value may underlie differences in student resource choice.

Understanding what drives student perceptions of value, and consequently resource choice, is important not just in theory, but also in practice, because of how resource choice might be influenced by others and the potential outcomes of these choices for individual students. For example, many mentors within science, engineering, technology, and mathematics (STEM) domains rely on their own experiences when recommending resources to students. While these assumptions are founded on experience within academia, previous research has shown that graduate students' perceptions and choice of resources is related to demographic variables, like their racial and gender identity (Weatherton & Schussler, 2022). As such, assumptions made by leaders within STEM, who are majority white or Asian males (National Center for Science and

Engineering Statistics, 2021), may not align with the different needs of the STEM student populations, which are increasingly diversifying in terms of racial and gender identity (National Center for Science and Engineering Statistics, 2021). Furthermore, given extant issues with retention in STEM graduate programs, it is critical to understand the potential relationship between resource choice and graduate student outcomes, like persistence (Okahana et al., 2018). However, before we can explore potential misalignments or outcomes, we first need to know basic information about what drives student resource choice and how these choices may differ across student demographic groups. Thus, this exploratory, qualitative study examined life science (LS) graduate students' perceptions of resource value, and how these may change across demographic groups, by examining student explanations about why certain resources are highly valuable to them.

### ***EXPECTANCY-VALUE THEORY FOR HELP SOURCES***

This study utilized Expectancy-Value Theory for Help Sources (EVTHS) as its theoretical framework to inform research questions, methodology, and interpretation of results (Luft et al., 2022). Proposed by Makara and Karabenick (2013), EVTHS states that students' help-seeking outcomes (i.e., resource choice) are driven by students' expectations and values for any given resource. Specifically, the model includes two components of prospective expectations: 1) perception that the resource will be available and accessible, and 2) perception the resource will provide help. Value, as outlined by EVTHS, has four components: 1) the type of help provided, 2) the relevance of help provided, 3) the quality of help provided and, 4) the accuracy of the help provided (Figure 1). Within EVTHS and its theoretical predecessor, Expectancy-Value Theory, expectations and values are hypothesized to be positively correlated, and empirical work supports this claim (Wigfield & Eccles, 2020). Previous work has argued that expectations and values may interact in a multiplicative way (Nagengast et al., 2011; Trautwein et al., 2012), though other studies have refuted this claim and many in the field continue to use an additive model of expectations and values (Eccles & Wigfield, 2020; Barron & Hulleman, 2015; Schnettler et al., 2020). These conflicting results may suggest that perceptions and values are conceptually very strongly linked and may even overlap in participants' minds; though, regardless of their conceptual overlap, both expectations and values have been repeatedly shown to impact students' achievement, persistence, and other academic outcomes (see Wigfield et al., 2009 for review).

The theoretical backing of EVTHS has been repeatedly tested within populations of undergraduate students and has demonstrated evidence of validity. For example, Evenhouse and colleagues (2020) indicated that undergraduate students' expectations of resource availability were important drivers of resource preferences; students in this study preferred to use resources which were readily accessible, such as online discussion forums and search engines, as opposed to homework solutions posted after corresponding assignment due dates or office hours, highlighting the impact of expectations of availability on student resource choice. Similarly, Tinsley and colleagues (1982) demonstrated a pattern of resource usage in undergraduate students based on the type of help they were seeking; for example, students were more likely to turn to close friends for personal help, while they would more likely ask instructors for help with career problems. These studies highlight the empirical support for the relationship between

expectations, values, and resource choice in undergraduate students. Within graduate students, our previous work has shown preliminary support for EVTHS, with LS graduate students' perceptions of resource usefulness and frequency of use to be positively correlated (Weatherton & Schussler, 2022).

The present study sought to further examine the applications of EVTHS within a graduate student population by probing one component of the model, student perceptions of resource value. We chose to focus on value, as opposed to expectations, to attempt to isolate participants' current perceptions driving their resource choice. Thus, we examined LS graduate students' perceptions of resource value, its impact on resource choice, and whether value perceptions differ across student demographic characteristics.

### ***PREVIOUS STUDIES OF GRADUATE STUDENT RESOURCE CHOICE***

For decades the field of graduate education has underscored the importance of a handful of resources: students' advisors, departmental structures, financial aid (Girves & Wemmerus, 1988; Lovitts, 2002; Sverdlik et al., 2018; Tinto, 1993). Much of this work has focused on the relationship between the use of certain resources and student success (e.g., the use of 'thesis supervisors' resulted in greater academic success, Garcia et al., 1988). However, relatively few studies have examined graduate students' perceptions and choices among the resources available to them beyond academic advisors. In this brief review of the literature, we will highlight research on graduate students' use and perceptions of social and material resources.

**Social resources:** Social resources are integral to student success and well-being and as such, have been central to studies of graduate education for decades (Griffin et al., 2020; Lovitts, 2002; Sverdlik et al., 2018; Tinto, 1993; Wofford et al., 2021). Resources that fall into this category are diverse and include both academic and non-academic relationships, like advisors, lab mates, significant others, and family members, among others. In particular, the student-advisor relationship is often heralded as the most important factor in the graduate school experience and thus has been extensively studied (Sverdlik et al., 2018). A students' choice of advisor is driven, in part, by their values related to the advisor (e.g., quality of advisor's reputation, type of help provided by advisor), validating the relationship between students' perceptions and their resource choice (Zhao et al., 2007). Students' primary advisors facilitate many goals, including academic, personal, affective, and career goals (Blanchard & Haccoun, 2020; Gisemba Bagaka's et al., 2015; Lovitts, 2002; Tuma et al., 2021; Zhao et al., 2007). However, for many students, including minoritized students (i.e., those historically excluded from higher education on the basis of gender identity, sexual orientation, race, or ethnicity), perceptions of support from peers or family members are often greater or equal to the support provided by primary advisors (Allen & Joseph, 2018; González, 2006; Holloway-Friesen, 2021). For example, a study of minoritized graduate students' social networks found that their social support came primarily from minoritized peers (e.g., lab mates, other graduate students) (Tullis & Kowalske, 2021). Furthermore, graduate students have previously cited the importance of family members and significant others for providing psychosocial (e.g., emotional support, motivation) and material (e.g., financial support, childcare) support (Breitenbach et al., 2019). These findings highlight the importance of social resources beyond advisors, as well as evidence for potential misalignments between a theoretical understanding of graduate student resource choice (i.e., the student-advisor relationship is one of the most important sources of support in

academia), and the lived reality of many graduate students, who may perceive other resources as equally or more valuable.

**Material resources:** Material resources, such as lab equipment or grant funding, provide some of the most basic support for graduate students' progress through their degrees, though these resources are often overlooked in empirical examinations of student success (Knight et al., 2018; Sverdlik et al., 2018; Wollast et al., 2018). A recent survey of LS graduate students found that students reported material and financial resources—like academic stipend, online academic journals, electronic resources, and grants—to be highly useful and frequently used (Weatherton & Schussler, 2022). However, many students report that the material resources they receive to be inadequate; in a recent survey of chemistry graduate students, almost half of respondents (46%) reported the need for greater support, both financial (e.g., greater stipends) and physical (e.g., updating lab equipment or infrastructure) (Stockard et al., 2022). While it is clear that material resources are important to students, it is unclear whether all material resources are equally valuable and how students choose between the many material resources available to them.

### ***CURRENT STUDY***

Clearly, there are a number of resources which graduate students choose to use and perceive to be highly valuable, but it is unclear what drives student perceptions of resource value and how perceptions of value may vary across resources. Perceptions of value are critical to understand as they empirically and theoretically impact resource choice and may ultimately impact graduate student outcomes. Utilizing Expectancy-Value Theory for Help Sources as our theoretical framework, this qualitative study explored life science (LS) graduate students' choice of their highest-value resources, their explanations about why they chose those resources, and how students' perceptions of value differed among resources and across demographic characteristics. Specifically, we addressed two research questions: 1) What resources do LS graduate students consider to be the most important? 2) What drives LS graduate students' perceptions of resource value?

## **METHODS**

### ***DATA COLLECTION***

Data for this study were collected during the Fall of 2021 as part of a national survey of LS graduate students. For more details about the survey and recruitment information, see Weatherton & Schussler (2022). This study was approved by the Institutional Review Board before data collection (IRB #20-05870-XP).

The survey collected data about what resources students used in their graduate program, how often they used these resources, and how they perceived these resources. Data for this study came from two survey questions, which asked students to choose the three resources that were the most important to them (*"Of the resources that you use, choose the 3 most important resources to you"*), and then asked, for each of the three resources, why it was selected (*"Please describe why you feel that this resource is important"*). Students did *not* rank these resources in terms of importance, they simply chose the three resources most important to them.

These two free-response questions underwent two rounds of pilot-testing (N=32 students total) to ensure that the questions were interpreted similarly across students and that the wording of the questions was not confusing (Weatherton and Schussler, 2022). Pilot testing showed that ‘importance’ was a more understandable word than ‘value’ for students in our population, so we used “most important” in our survey questions to refer to the concept of high-value resources. This study sought to collect qualitative data focused on students’ perception of resource value, not their expectations, and thus, we only pilot tested whether ‘importance’ was an adequate proxy for the concept of resource value, though it may have captured some aspect of students’ expectations of the resource as well (see *limitations*). Given this, we were attentive to all student responses in this study, including those that may not have fallen under the strict definition of value.

At the end of the survey, participants were asked a suite of demographic questions, which they could choose to skip. The questions gathered the following data: participants’ gender identity, race, year in their graduate program, and college generation status (i.e., whether they identified as first-generation college students or not).

## **DATA ANALYSIS**

**Data cleaning.** We received 668 responses from LS graduate students across the United States. 135 responses were removed because they did not complete the survey. We also removed 18 survey responses that did not answer the free-response questions and 5 responses from participants who selected more than 3 important resources. 18 uncodeable responses were removed during the process of data analysis. Thus, the final sample size for this study was 492.

**Qualitative analysis.** Two researchers (M.W. & B.V.) conducted qualitative analysis on participant explanations about why they chose their three most important resources (1533 free responses). We followed a basic qualitative analysis procedure, in which responses were first inductively coded (open coding), similar codes were combined (axial coding), and then codes were sorted into broader categories (i.e., themes) (Elliott, 2018; Merriam & Tisdell, 2015; Skjott Linneberg & Korsgaard, 2019). Throughout the process, both researchers made a conscious effort to “bracket,” or set aside, their preconceptions of what may drive student perception of value and the study’s theoretical framework, in order to examine the responses as impartially as possible (Patton, 2014).

Each researcher independently read all student responses to conduct their initial open coding, and researchers used descriptive coding methods to note code(s) that summarized main ideas from students’ responses. After initial open coding, the researchers met to discuss their codes and develop a codebook based on codes they agreed were represented in the data. While the original intent of the study was to capture students’ perceptions of resource value, during analysis we noticed that participants also often discussed their expectations of resources. In accordance with a qualitative, constructivist epistemology (i.e., that there is no one ‘correct’ answer to survey questions; Merriam, 2009) and our inductive coding process, we decided to keep all student responses, regardless of whether they discussed resource value or not. The initial codebook was then tested independently by each researcher on the same set of 100 randomly selected responses; the codes for these responses were then compared to ensure an adequate level of inter-rater agreement (i.e., the degree to which raters consistently distinguish between different responses, Gisev et al., 2013; Patton, 2014; Hruschka et al., 2004). Interrater agreement



is a critical component of qualitative coding as it enhances the consistency and reliability of qualitative work, which is inherently liable to coders' subjectivity. Interrater agreement was calculated by dividing the percent of responses that the coders agreed on by the total number of responses. While responses could receive multiple codes, agreement was only met when *all* assigned codes for that response matched between the two coders. After a round of testing, the codebook was then modified based on researchers' discussions. This process was repeated until interrater agreement was consistently above 70% on sets of 100 responses, after which both researchers independently coded the entire dataset (Hruschka et al., 2004).

Researchers did not code responses under 3 words (e.g., "useful", "my income"), or responses that were too vague or missing too many words to understand. Researchers did not code responses that described the resource itself as opposed to answering the question (e.g., [Research collaborators] "collaborations/publications"; [University library] "Covers the majority (*sic*) of papers from past to present"). After removing these uncodeable responses, the final dataset included 1262 student responses from the 492 participants.

After both researchers independently coded the entire dataset, the primary author (M.W.) identified any disagreements in the two sets of codes. The final agreement percent was 73%. The researchers then reconciled all coding conflicts via discussion, so that codes were 100% consistent between the two coders (Gisev et al., 2013; Hruschka et al., 2004). After this stage of coding was completed, the primary author (M.W.) sorted codes into broader themes, and these themes were discussed with a group of education researchers. The final themes and codes, along with descriptions and examples of each code from participant comments, are shown in Table 2.

We analyzed and visualized our results in R Studio (ver. 1.2.5) using the base (Rstudio team, 2020), ggplot2 (Wickham, 2016), and ggpubr (Kassambara, 2022) packages.

## **VALIDITY**

As opposed to quantitative research, qualitative research uses non-numerical information, such as individual perceptions, experiences, and cognition, as data. The topics are inherently subjective – they are influenced by the personal feelings or opinions of the research participants—and the process of interpreting participants' experiences via a research team adds another layer of subjectivity and potential bias. Participant-based subjectivity is an essential and inevitable aspect of qualitative work, while researcher-based subjectivity can add important context and nuance to research findings (Leung, 2015). Our goal as qualitative researchers is to orient readers to this subjectivity and reduce our own biases as much as possible (Leung, 2015; Merriam & Tisdell, 2015). Thus, we undertook several precautions to reduce our biases and ensure the reliability and rigor of our work.

First, we used a method of constant comparison when creating the codebook to ensure that the codebook accurately reflected students' free response answers, thereby working to ensure the consistency and accuracy of our results (Leech & Onwuegbuzie, 2007; Patton, 2014). Throughout the process of analyzing and interpreting the data, we aimed to understand and bracket the biases that may influence our interpretation of the data, and this was done through a combination of memo writing and peer debriefing (Patton, 2014). We aimed for a high interrater score when conducting our analyses to establish the reliability of our results. We did not conduct a full analysis of the data until the two coders (M.W. and B.V.) consistently agreed more than

70% of the time, the standard for the field (DeCuir-Gunby et al., 2011; Hruschka et al., 2004). Ensuring that interrater agreement was both consistent and high provides assurance that individual researchers' biases have a minimal impact on data analysis and that the codebook was functional for our data. Finally, we used a non-coding expert (E.S.) to conduct a critical review of the codebook and interpretation of the data, which further increases the rigor of analysis and interpretation.

## RESULTS

### ***PARTICIPANTS***

Participant demographics are shown in Supplementary Table 1 (N=492). The majority of participants were in the first three years of their LS graduate program (65%). The majority of participants identified as women (70.7%) and white (71%). Our sample was approximately split between participants who identified as first-generation college students (51%) and continuing generation students (47.6%).

### ***RQ 1: WHAT RESOURCES DO LS GS CONSIDER TO BE THE MOST IMPORTANT?***

Of the 34 resources available for participants to choose from (Weatherton & Schussler, 2022, Supplementary Table 2), 31 resources were selected at least once by participants as one of their top three most important resources. Three resources—international student center, publishing funds, and university sponsored events—were not chosen by any participants.

'Advisor' was selected as a top three choice by the most participants (67.68%), followed by 'academic stipend' (56.71%), and 'significant other' (24.60%). Resources chosen least often by students included 'alumni network', 'departmental graduate student association', 'departmental seminars', 'social media', 'university career center', and 'university-sponsored workshops', which were all chosen once (Table 1). These trends stayed relatively consistent when broken down by demographic variables (Table 2). As shown in Table 2, 'advisor' was the most important resource for participants regardless of their demographic characteristics, followed by 'academic stipend'. 'Significant other' was the third-most often chosen resource for all demographic groups except men, whose third-most chosen resource was 'online academic journals'. Also of note, for participants who identified as gender non-binary (n=20), 'significant other' and 'lab mates' were tied for third-most chosen resource.

### ***RQ 2: WHAT DRIVES LS GRADUATE STUDENTS' PERCEPTION OF VALUE?***

When asked to describe why their selected resources were important, student free-response answers were grouped into nine codes, and these codes fell into two themes, 'resource attributes' and 'help provided' (Table 3). These theme names were guided by the nature of the codes and not EVTHS constructs; we also note that the codes that emerged from student responses encompassed both value and expectations.

Resource attributes included any codes where students described their perceptions of the **characteristics or nature of the resource that made it valuable to them**. Responses that were coded under the 'resource attributes' theme discussed the resource itself, as opposed to the outcomes produced by the resource (as in the help provided theme). Within resource attributes,

there were three codes, 'availability,' 'validity,' and 'essential,' which were coded 43, 81, and 59 times, respectively (out of 1816 total codes assigned).

The theme 'help provided' included six codes where participants described **what they used a resource for or what the resource provided for them**, these were 'basic needs,' 'connection,' 'academic,' 'persistence,' 'support,' and 'wellbeing'. Overall, academic and support codes were the most frequently used, with academic being coded 585 times (out of 1816 codes) and support being coded 459 times. Following these codes, wellbeing (267) and basic needs (236) were the next most common, with all other codes in the help provided theme being assigned less than 100 times (Table 3). Resources often provided many different types of help and thus, many participant responses were assigned multiple codes.

Participant responses often included codes from both themes (Figure 2). For example, when describing why previous mentors were an important resource, one participant said, "[previous mentors are] *invaluable resource for research questions; often more accessible or responsive than advisor or committee members.*" This quote includes both a code from the **resource attribute** theme (availability) and describes the **help provided** by the resource (academic). However, ten resources were solely described in terms of the help they provided to students (Figure 2). Figure 2 shows each of the resources that participants discussed and the proportion of codes representing the resource attributes or help provided themes. Below we will discuss each theme in depth and examine how codes within these themes differed across resources.

**THEME 1: Resource Attributes.** The code 'availability' was used 43 times and referred to participants' perceptions of a resources' convenience or accessibility. For example, participants often discussed that a resource was important to them because it was always available to help, "*My advisor...is consistently available to help answer my questions or concerns.*" Both social and material resources (e.g., advisor, electronic resources, family members, university library) were often described using availability, when students described that they interacted with these resources often, or they could rely on them to be available for help (Figure 3). The resource most often associated with this code was advisor, which participants described as being important because they were often available when they needed them, or they met frequently.

The code 'validity' was coded 81 times and referred to participants' expectation that a resource would give out correct, helpful, or trustworthy information. For example, a participant discussed the validity of online academic journals, "*I can find the answer to my questions from this reliable source.*" Advisor, department faculty, research collaborators, and lab mates were the resources most frequently described using the validity code, meaning that students felt these resources were important because of their ability to give them helpful or trustworthy information. Of those, advisor was most often associated with the code of validity (Figure 3).

The code 'essential' referred to participants' expectation that they could not complete some aspect of their program without the resource (i.e., it was essential to their graduate program or success generally) and was coded 59 times. This was often coded when participants discussed that without a certain resource, they wouldn't be able to continue in their program, for example, many participants discussed the necessity of their academic stipend, "*Without the stipend I would not be in school,*" "*Without it, a PhD was not affordable in my case.*" As opposed to the basic need code, essential was used when participants described that they needed a resource but did not

specify that it fulfills a basic need (e.g., food, shelter, paying bills). Monetary resources (e.g., travel funds, academic stipend, grants) were often described by the essential code, as well as university transit system, indicating that students perceived that these resources were integral to their persistence and success in their graduate program (Figure 3). By far, the resource most associated with the code of need was academic stipend, which participants often discussed in terms of this resource allowing them to focus on their academic work or attend their program.

**THEME 2: Help Provided.** The code ‘basic need’ was used whenever participants described that a resource provided some form of food, shelter, security (physical or positional), or similar. Basic need was coded 236 times. Researchers used the list of basic needs used by the Human Needs Index to identify what needs constituted a basic need (Salvation Army, 2022). Resources that provided basic needs were often monetary resources that afforded students the ability to pay for rent or buy food. For example, a student described the importance of their academic stipend in this way: *“My stipend is important because being a graduate student is my job. Therefore, I need financial resources to be able to stay afloat by paying rent, for food, etc.”* By far the resource that was most often mentioned in relation to basic needs was academic stipend, followed by mental health counseling and the university health center (Figure 4).

The code ‘connection’ was used whenever participants described that a resource connected them to other resources or provided them with access to other resources. Connection was coded 77 times. Students described that some resources were valuable because they allowed them to access other resources, as this participant described, *“[University library] Allows me to search for and read relevant journals that would otherwise be inaccessible.”* Furthermore, advisors or faculty members were valuable to students as they often connected them to resources that they were otherwise unaware of, *“My advisor provides opportunities that cover many of the items that are important. So with a good advisor, it won’t matter what the institution provides, they’ll help you find the resources you need.”* Advisor and online academic journals were the resources most often coded with connection (Figure 4).

The code ‘academic’ was the most prevalent code in the dataset and was identified 585 times; this code was used whenever participants described that a resource was important to them because it helped them accomplish an academic- or career-related task (e.g., analyzing their data, learning a new procedure, or brainstorming dissertation ideas). For example, when describing the importance of university research facilities, a student said: *“These resources enable my data generation and my research would not be possible without them.”* In the same way that material resources, such as research facilities, help to accomplish academic goals, participants described that social resources, such as lab mates, were equally helpful in accomplishing academic tasks or learning new skills, *“I have a very experienced laboratory scientist in the lab who has been instrumental in my lab skill development and thesis.”* Many of the resources surveyed provided academic help to participants, and advisor was the resource most often coded using the academic code (Figure 4).

The code ‘persistence’ was coded 78 times and was used whenever participants described a resource helping them fulfill an affective need related to completing their degree. As opposed to the academic code, wherein resources helped to complete material tasks related to degree acquisition, the code persistence was used when resources helped participants mentally to continue toward degree acquisition. This was often in the form of the resource motivating or encouraging students; for example, two students wrote similar sentiments about their advisors:

*“Keeps me going,” “Keeps me on track.”* Family members, too, often provided essential motivation for participants, *“My family consistently encourages me to keep going even when times get tough.”* Social resources, like advisor, significant other, research collaborators, and family members were all frequently coded with persistence, and of these, advisor was coded most often (Figure 4).

The code ‘support’ was the second most prevalent code in the dataset and used 459 times; this code was used whenever participants described that a resource was important to them because it provided them with support, guidance, or mentorship. This included providing feedback, general guidance, or space for participants to express their feelings. For example, in describing the importance of their advisor, a student wrote: *“My advisor helps me with everything and has given me incredibly useful guidance throughout my graduate degree”*. Support often came from non-academic resources as well, like therapists or other mental health counseling, which often supported students by providing a place to vent and a listening ear: *“The rollercoasters of grad school, although felt by most, can be immensely heavy at times. My therapist helps me productively work through these feelings and thoughts.”* Social resources, like advisor, significant other, lab mates, and other graduate students were all frequently coded with support, and of these, advisor was coded most often (Figure 4).

The code ‘well-being’ was used whenever participants described that a resource was important to them because it helped with their mental well-being by reducing stress or improving mental health and was coded 267 times. Resources that helped with participants’ well-being often did so by making participants feel loved, providing emotional or social outlets, or a sense of community. For example, a participant described why friends were one of their most important resources, *“Seeing friends allows me to blow off(f) steam, escape from the stress of grad school for hours at a time, try new things in my city, etc.”* In this example, friends were an important resource because they allowed the participant to destress and maintain a healthy work-life balance. Similarly, significant others were often mentioned as important resources for maintaining students’ well-being: *“Grad school is inherently stressful- having support at home that isn’t academic really helps destress”*. Significant others and friends were most often coded as fulfilling participants’ well-being needs (Figure 4).

**Code prevalence across demographic characteristics.** Table 4 shows how codes in participants’ responses for the top 3 most frequently chosen resources varied across participants’ demographic characteristics. Percentages in this table represents relative frequency of code prevalence. Regardless of participants’ demographic characteristics, most resources were described with a relatively similar code prevalence. For example, student responses about their advisor were codes using the ‘academic’ code approximately a quarter of the time, regardless of student demographic characteristics (e.g., 25% code prevalence for first generation students versus 23% for continuing generation students; and 24% of code prevalence for women compared to 24% for men). For a full comparison of how code prevalence differed across demographic characteristics for all resources, see Supplementary Table 3.

## DISCUSSION

This study addressed two research questions: 1) What resources do LS graduate students consider to be the most important? 2) What drives LS graduate student perception of resource value? Regardless of their demographic characteristics, the majority of our respondents

considered two resources most important – advisor and academic stipend. However, many other resources were selected as important by participants, albeit at a much lower frequency than advisor and academic stipend, suggesting that considerable diversity exists within student perceptions of resource importance, but that this diversity in perception may not have a strong relationship with students’ demographic characteristics. Participants’ descriptions of why that resource was important to them supported all four components of value outlined by EVTHS, though notably participants also often described their expectations of the resource. Once again, these descriptions did not vary much by demographic group, suggesting an unexpected uniformity in the “most important” resources for graduate students. We were also surprised by the number of responses focused on the type of help provided by the resource; this may indicate that some components of value (i.e., the type of help provided by resources) are more salient than others in students’ resource choice decisions. Finally, student responses revealed that the same resource can be perceived as having multiple values, suggesting a diversity of ways that individuals may perceive, and accordingly choose resources. Below, we discuss the implications of these findings in more detail and how they may apply to future research, policy, and practice.

### ***EXPECTATIONS AND VALUES: THEORETICALLY CONFOUNDING VARIABLES***

While our study set out to investigate one component of EVTHS, resource value, we found that graduate student responses also aligned with aspects of EVTHS’ concept of ‘expectations’. For example, ‘availability’ is a component of expectations as outlined by EVTHS. These results indicate that our study likely did not exclusively capture students’ perceptions of resource value, but instead captured both expectations and values. These results could indicate that expectations and values are strongly linked, as supported by current literature (e.g., Wigfield & Eccles, 2020) indicating a multiplicative interaction between expectations and values (Trautwein et al., 2012). It may also be that expectations and values were linked for resources that are used most frequently by graduate students because the concepts of immediate use and prospective use are also confounded; an advisor is seen as useful in the future because they have already demonstrated utility in the present, for example. Future research should investigate whether expectations and values can be disentangled and, if so, develop methods to evaluate each component separately. While expectations and values were confounded in our results, many of our codes closely aligned with the four components of value hypothesized by our theoretical framework. For example, our codes ‘type of help provided’ and ‘validity’ are analogous to theoretical components of value ‘expected type of help’ and ‘quality of help,’ respectively. These results indicate support for the use of EVTHS in LS graduate student populations, though additional theoretical clarity is needed.

### ***THE SURPRISING SIMILARITY AMONG DEMOGRAPHIC GROUPS***

We disambiguated the data by demographic characteristics for both of our research questions and found few indications that demographic characteristics varied for high-impact resource importance or how students described resource value. In regard to our first research question, we found that while there were some resources chosen by certain demographic groups of participants that were never chosen by others (e.g., ‘university career center’ was chosen as

important by *one* continuing-generation student, but never by first-generation students), the number of students choosing these resources is too small to be able to draw conclusions about the relationship between resource perception and student demographics broadly. Similarly, in terms of our second research question, we found that student perception of resource value (i.e., prevalence of response codes across student responses) did not reveal any major patterns or differences across demographic characteristics.

As opposed to existing literature on student perception of value (e.g., Eccles et al., 1993; Ruble, Martin, & Berenbaum, 2006; Wigfield et al., 2015), our results do not suggest a strong relationship between resource perception and demographics. One potential explanation for this null effect is a filtering effect of higher education; most studies on resource perception are conducted at the K-16 level (e.g., Eccles et al., 1993; Guthrie et al., 2007; Chiang et al., 2011). If the use and perception of resources are linked to academic success, students at the graduate level may represent the outcome of a filtering process. Thus, students at the graduate level would have similar perceptions of resources, regardless of demographic characteristics. It may also be, however, that the top three most important resources represent a ‘ceiling effect’ where they are so generically useful to graduate school that no differences would be seen. In this case, differences would be expected to be seen in less frequently used resources, as we found previously (Weatherton & Schussler, 2022). More research is needed to evaluate the relationships between demographic characteristics, academic success, and resource use to evaluate whether resource use is a factor in differential degree attainment. Future work should continue to examine differences in resource perception across demographic groups, potentially using qualitative methods to dive deeper into perceptions that may impact students’ resource use.

### ***THE MAJORITY OF PARTICIPANTS CONSIDERED ADVISOR, ACADEMIC STIPENDS TO BE IMPORTANT, REGARDLESS OF DEMOGRAPHIC CHARACTERISTICS.***

The finding that advisor and academic stipend were chosen most frequently as an important resource is consistent with previous work showing the overwhelming importance of social and financial resources for graduate students’ well-being and academic success (Blanchard & Haccoun, 2020; Lovitts, 2002; Sverdlik et al., 2018; Tinto, 1993). Our results indicate that this seems to be generally true regardless of the demographic group of the graduate student. Although advisor and academic stipend were chosen frequently by participants in our study, there was an astonishing diversity of other resource choices among the participants. Indeed, 23 of the 31 resources that were selected as important were selected by fewer than 50 participants, or 10% of our sample. These findings validate the notion that university leaders and mentors cannot make assumptions about what resources are important to students. Resources that were chosen less frequently, like university transit system, departmental seminars, or university-provided research facilities were clearly important to some students, however, relatively little research has been done to explore these resources and their impacts on student outcomes (as opposed to resources like advisor or lab mates). Thus, our results provide multiple avenues for future research into the resources that LS graduate students feel are important, and which may be integral to improving student outcomes. Overall, our results indicate that advisors, mentors, and institutions should continue to foster supportive social relationships and facilitate opportunities for graduate students to secure funding. Mentors and department leaders should also be

encouraged to engage in conversations with students about their resource needs and perceptions of value, to collect individual-level data upon which to make mentoring and policy decisions.

### ***GRADUATE STUDENTS' PERCEPTIONS OF IMPORTANCE ARE DRIVEN BY WHAT KIND OF HELP THE RESOURCE PROVIDES***

While participants mentioned both expectations and values, the majority of responses centered around one component of value: 'expected type of help' (i.e., codes in our help provided theme). Student perceptions of this aspect of value are not often evaluated and many expectancy-value scales lack items pertaining to this component (Flake et al., 2015; Wigfield & Eccles, 2000). Thus, our results indicate that student expectations of the type of help a resource will provide may be an integral but understudied aspect of student resource choice.

Within the theme of help provided, academic and support codes were most prevalent, indicating a priority among this population for resources that provided academic help or supported them in some way. This finding aligns with previous work that indicates academic and mentoring supports are integral to the success and well-being of graduate students (Sverdlik et al., 2018; Tullis & Kowalske, 2021). However, much of the extant literature related to graduate student academic support focuses on single resources, such as advisors, while our participants described using a myriad of resources to receive academic help. Indeed, participants described that they received academic help from 22 of the 31 resources surveyed (Figure 4). The variety of sources from which our participants sought academic help further validates the notion that the field of graduate education has not fully explored graduate student resource choice and more empirical data is needed to understand graduate students' complex behaviors and perceptions as they relate to resource choice.

Beyond academic help and support, our results highlighted the importance of resources that fulfilled students' basic needs, which are often overlooked by graduate programs and institutional policy (Oh et al., 2022; Zahneis & June, 2020). Participants in our study overwhelmingly described the importance of their academic stipend, with 57% of participants choosing it as one of their top 3 most important resources, and of these participants, 95% mentioning that academic stipend was important to them, in part, because it fulfilled their basic needs. Academic stipend conferred participants the ability to pay their bills, afford housing, and generally worry less about struggling financially. Although the current extent of food and housing insecurity in graduate student populations is unclear (Nazmi et al., 2019), our results suggest that a large proportion of graduate students are concerned about being able to meet their basic needs. Studies of undergraduate students have revealed that food and housing insecurity is related to poor mental health and lower academic persistence (Oh et al., 2022; Phillips et al., 2018), highlighting the cascading effects of students being unable to fulfill their basic needs. Future research should investigate the extent to which resources offered by graduate programs, and specifically academic stipends, are able to fulfill students' basic needs. Furthermore, future work should explore the effects of unmet needs on student outcomes within graduate student populations.



## ***COMPONENTS OF RESOURCE IMPORTANCE DIFFER ACROSS RESOURCES***

Our results revealed substantial variation in the codes that made up participants' perceptions of resource importance across resources in our study, with some resources having multiple codes associated with them, while others were only seen as important due to the help they provided in one area (i.e., were only described using one 'help provided' code). For example, lab mates and friends both provided five different types of help—academic, connection, support, persistence, and well-being (Figure 4). On the other hand, resources like university gym and departmental administrators only provided one type of help, well-being, or support, respectively (Figure 4). We found no identifiable pattern across resources in terms of the diversity of types of help they provided (Supplementary Table 3). For example, social resources (e.g., advisor, significant other) generally were perceived to provide many different types of help, but other social resources like alumni network did not show the same trend. Thus, it's unclear what aspects or characteristics of a resource may lead to multiple perceptions of types of help, or more broadly, what aspects of a resource inform student perceptions of importance and value. However, the demonstrated variation among resources and the components of importance described by participants reveals interesting avenues for future research, and this variation should be further investigated in LS graduate students and in other populations (e.g., undergraduate students, graduate students within other domains). Future work could investigate whether perceptions of resource importance are stable across time and if so, how components of importance align with certain resources (e.g., examine whether certain resources are preferentially valued for their validity, while others are valued for their availability) and how that informs overall resource choice. A more nuanced understanding of how perceptions of importance differ across resources could inform institutions and mentors about highly impactful resources or which resources to recommend to students based on the type of help students are seeking.

## ***AN ACADEMIC HIERARCHY OF NEEDS***

Our results indicated that LS graduate students' perceptions of their most important resources are driven, in part, by their attempts to fulfill needs. Furthermore, our results show that while graduate students are likely to have similar needs, each student will have unique perceptions of these needs and unique ways of fulfilling them. Therefore, an important take-away of these results is that institutions, departments, and mentors must gather similar qualitative data about their own students to understand how to best support them. Below, we use Maslow's Theory of Human Motivation (1943) to further understand these results and how to apply them to current thinking and practice within higher education.

The Theory of Human Motivation states that individuals have an increasingly complex set of needs that they strive to meet, including physiological and psychosocial needs, and that the goal of fulfilling these needs motivates individual behavioral choices. This theory is often visualized by a pyramid of needs, with more basal needs at the bottom (e.g., physiological and safety needs) moving towards more complex needs (e.g., self-esteem and self-actualization needs) at the top (Bridgman et al., 2019; De Bruyckere et al., 2015). However, this visualization, and the coinciding idea that needs must be met in a hierarchical, stepwise order was not proposed by Maslow; instead, the theory indicated that while needs move from basal to complex, individuals may aim to meet multiple needs at once (Maslow, 1943). We see similar trends in our results,

where participants identified that some resources, like their academic stipend, help them to fulfill both basic and academic needs (e.g., “*I would not be able to focus on my graduate education, or have access to education without this stipend to pay rent and buy food.*”). Participants also discussed resources that helped them to fulfill more complex needs, like self-esteem and self-actualization. For example, realizing one’s talent and potential are key aspects of self-actualization, and participants often cited their advisor as helping them to realize their scientific potential, as these three participants said similarly: “*(my advisor is) central to developing as scientist,*” “*propels me in my academic development,*” “*helps me development as a scientist.*” Maslow’s theory provides a useful framework to identify the holistic needs of graduate students; combining this framework with the results of this study, we propose an adapted model of academic needs that may be used in future work to explain the needs and resource choices of graduate students. This model, like the original theory proposed by Maslow, is organized from basal to more complex needs and includes physiological, academic, social, esteem, and self-actualization needs (Figure 5). Also included in the model are examples of resources that may help students to achieve those needs, though as previously mentioned, resources may fill multiple needs, needs may be fulfilled by multiple resources, and different students are likely to use different sets of resources to fulfill the same needs. This model recognizes that needs overlap considerably and that the process of fulfilling these needs does not happen linearly, thus the reciprocal arrows between needs.

This model adds to the literature by providing nuance that is specific to higher education settings in the form of *academic* needs and mention of resources specific to graduate students, and thus is a useful adaptation for future studies of student needs, value perceptions, or resource choice. Utilization of this model will allow researchers to consider graduate students and their needs more holistically, which in turn may allow for the advancement of policy which considers all aspects of graduate students’ needs. This model may also be used as a tool for those in higher education. For example, institutions may use it to evaluate the extent to which graduate students’ needs are being fulfilled by certain policies, or mentors and graduate students may use it to identify current and future needs and how to fulfill them. For example, a mentor and graduate student could talk about the students’ unique academic needs and what resources they might draw on to fulfill them, identifying gaps and potential professional development opportunities. We believe that utilizing this model to facilitate these discussions represents important mentoring opportunity, as identifying student needs and resources to fulfill them may be, for some students, part of the academic ‘hidden curriculum’ of aspects of graduate school that are not explicitly discussed. As previous literature has shown, students struggle to achieve success when components of their needs are not met (González-Betancor & Dorta-González, 2020; Oh et al., 2022; Phillips et al., 2018); thus, we believe that a greater focus on striving to fulfill all of students’ needs will lead to an increase in students’ well-being and academic success.

## ***LIMITATIONS***

We are mindful of several limitations that limit the scope and generalizability of our work. Specifically, we recognize that our participant sample is not fully representative of LS graduate students broadly, and thus conclusions drawn from our work may be missing important perspectives. As with our previous work drawn from the same survey, our participant pool was over-representative in terms of white students (71% of our participants, compared to 47% of LS graduate students broadly, National Science Board 2020) and female students (70.8% in our sample compared to 55.8% in LS graduate programs broadly; National Science Board, 2020). These participant-level limitations limit the generalizability of our findings beyond our sample. Future research should work to validate the patterns found in our results in more diverse population pools (in terms of racial and gender diversity, as well as in terms of study domains) to further explore the nuance within student perceptions of value.

Furthermore, survey-level limitations included resources missing from the survey which students may have found important and issues with overlap between the concepts of expectations and values. As with our previous work drawn from the same survey, participants wrote in 20 unique resources that were missed during survey development and were not included in our list. These ‘missing’ resources may have been highly important to students, though because they were not included in our survey list, we were unable to collect data related to them. Thus, our results do not represent a fully comprehensive examination of the resources that are important to students. Future work may circumvent this limitation by allowing students to write-in resources that are not included in the survey.

As previously mentioned, although this study set out to solely examine students’ perception of resource value, our results included aspects of expectations (as outlined by EVTHS). This may indicate that our survey question was not clear enough to exclusively collect students’ perceptions of value, or because surveys about resource choice are an inherently retrospective endeavor (i.e., we are asking about choices that have already happened), values and expectations are inextricably linked concepts. Future research should work to more fully understand students’ definitions of resource value and resource expectation so that more refined survey questions can be created to separate the two concepts.

Finally, we recognize that qualitative work is inherently limited by our own experiences and biases. We took many steps to address the validity and trustworthiness of our methods (*see validity*). While we have done our due diligence to explore, understand, and bracket our internal biases as they relate to interpreting data, there will always be limitations inherent to a qualitative study that stem from who is interpreting the data, and thus our results and conclusions should be interpreted in light of this fact.

## **CONCLUSION**

This study asked questions about LS graduate students’ resource choices and the values associated with those choices. Using EVTHS and qualitative methods we found that LS graduate students perceive a variety of resources to be important to them, and that these choices were driven largely by the type of help participants felt that the resources provided. Although we asked specifically about value, participants often discussed their expectations for a resource, as well as their values, indicating that expectations and values may be fundamentally linked. Based on our results, we have proposed a novel way to understand graduate student resource choice: an

academic hierarchy of needs. While this study provides important insights about why graduate students use certain resources, future work is needed to understand how resource choice is related to student outcomes (e.g., academic success, well-being, persistence) and how student perception of resources may change over time. Resource utilization is a ubiquitous and essential aspect of the graduate student experience, though much diversity exists within this process. Further research examining the complexity of this process will allow mentors, advisors, and leaders of institutional change to tailor resources for graduate students and ultimately help improve their experience as graduate students.

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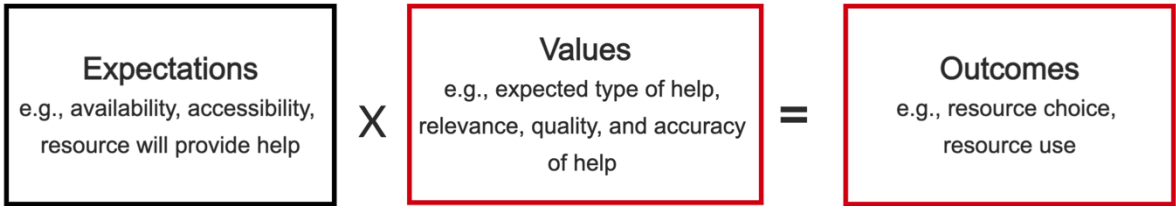
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APPENDIX 4



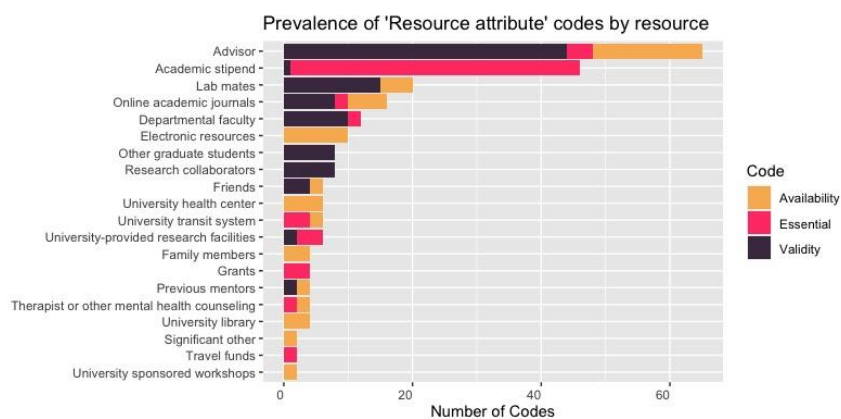


Figure 4.2: Prevalence of each code (by frequency) within the ‘resource attributes’ theme for each resource

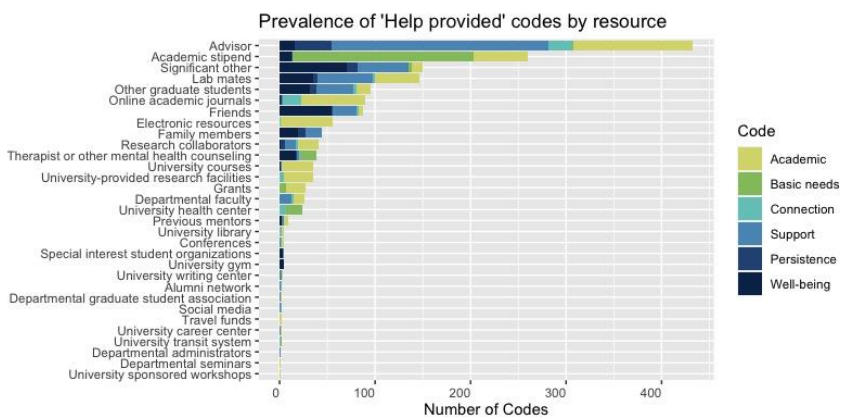


Figure 4.3: Prevalence of each code (by frequency) within the ‘help provided’ theme for each resource

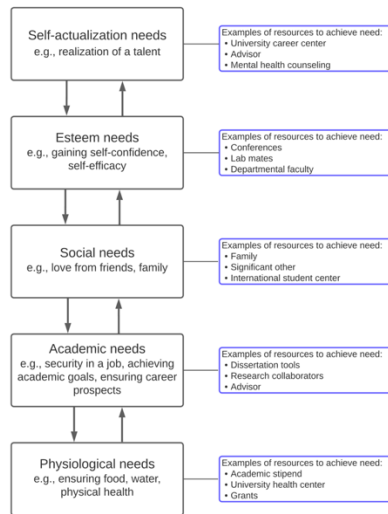


Figure 4.4: Our proposed academic hierarchy of needs. Black boxes indicate needs, arrows indicate the possibility of fulfilling multiple needs at once, and blue boxes represent example resources that students may use to fulfill need.

Table 4.1: Resources ranked by the number of times they were selected as a top three resource choice by graduate student participants (N Total = 492)

| Resource                                    | Frequency | Percentage |
|---------------------------------------------|-----------|------------|
| Advisor                                     | 333       | 67.68%     |
| Academic stipend                            | 279       | 56.71%     |
| Significant other                           | 121       | 24.59%     |
| Online academic journals                    | 100       | 20.33%     |
| Lab mates                                   | 96        | 19.51%     |
| Friends                                     | 82        | 16.67%     |
| Other graduate students                     | 70        | 14.23%     |
| Electronic resources                        | 68        | 13.82%     |
| Family members                              | 45        | 9.15%      |
| Therapist or other mental health counseling | 45        | 9.15%      |
| University courses                          | 39        | 7.93%      |
| Research collaborators                      | 36        | 7.32%      |
| University-provided research facilities     | 34        | 6.91%      |
| Grants                                      | 27        | 5.49%      |
| Departmental faculty                        | 21        | 4.27%      |
| University health center                    | 20        | 4.07%      |

Table 4.1 continued

| Resource                                  | Frequency | Percentage |
|-------------------------------------------|-----------|------------|
| University gym                            | 10        | 2.03%      |
| University library                        | 10        | 2.03%      |
| Previous mentors                          | 8         | 1.63%      |
| Conferences                               | 6         | 1.22%      |
| University transit system                 | 5         | 1.02%      |
| Travel funds                              | 4         | 0.81%      |
| Special interest student organizations    | 3         | 0.61%      |
| Departmental administrators               | 3         | 0.61%      |
| University writing center                 | 2         | 0.41%      |
| Alumni network                            | 1         | 0.20%      |
| Departmental graduate student association | 1         | 0.20%      |
| Departmental seminars                     | 1         | 0.20%      |
| Social media                              | 1         | 0.20%      |
| University career center                  | 1         | 0.20%      |
| University sponsored workshops            | 1         | 0.20%      |

Table 4.2: Top three most frequently selected resources across participant demographic characteristics.

| Resource         | Demographic Characteristic | Relative percent within demographic category | Number of participants (N) |
|------------------|----------------------------|----------------------------------------------|----------------------------|
| Advisor          | Nonwhite                   | 66.20%                                       | 94                         |
|                  | White                      | 68.29%                                       | 239                        |
|                  | Continuing generation      | 69.66%                                       | 163                        |
|                  | First generation           | 64.94%                                       | 163                        |
|                  | Woman                      | 67.53%                                       | 235                        |
|                  | Man                        | 66.94%                                       | 83                         |
|                  | Years 1-2                  | 67.54%                                       | 154                        |
|                  | Years 3+                   | 67.80%                                       | 179                        |
| Academic stipend | Nonwhite                   | 52.11%                                       | 74                         |
|                  | White                      | 58.57%                                       | 205                        |
|                  | Continuing generation      | 55.13%                                       | 129                        |
|                  | First generation           | 58.17%                                       | 146                        |
|                  | Woman                      | 58.05%                                       | 202                        |

Table 4.2 continued

| Resource                 | Demographic Characteristic | Relative percent within demographic category | Number of participants (N) |
|--------------------------|----------------------------|----------------------------------------------|----------------------------|
| Academic stipend         | Man                        | 49.19%                                       | 61                         |
|                          | Years 1-2                  | 55.26%                                       | 126                        |
|                          | Years 3+                   | 57.95%                                       | 153                        |
| Significant other        | Nonwhite                   | 26.76%                                       | 38                         |
|                          | White                      | 23.71%                                       | 83                         |
|                          | Continuing generation      | 22.65%                                       | 53                         |
|                          | First generation           | 25.90%                                       | 65                         |
|                          | Woman                      | 27.59%                                       | 96                         |
|                          | Years 1-2                  | 24.12%                                       | 55                         |
|                          | Years 3+                   | 25.00%                                       | 66                         |
| Online academic journals | Man                        | 20.16%                                       | 25                         |

Table 4.3: Codebook showing themes, codes, code descriptions, example student responses, how often the code was identified within the data set by frequency and overall percentage (N=1816 codes).

| <i>Theme</i>        | <i>Code</i>  | <i>Description</i>                                                                                                                                      | <i>Example</i>                                                                                                       | <i>Frequency (N=1816 codes)</i> | <i>Percentage</i> |
|---------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|---------------------------------|-------------------|
| Resource attributes | Availability | Participants' expectation of the resources' convenience, ease of use, or accessibility                                                                  | [ <i>Advisor</i> ] ...She is always available when I need her                                                        | 43                              | 2.36%             |
|                     | Validity     | Participants' expectation that the resource is helpful, knowledgeable, trustworthy, or correct in terms of information or advice                        | [ <i>Departmental faculty</i> ] Faculty are the experts our department so they are a valuable resource of knowledge. | 81                              | 4.46%             |
|                     | Essential    | Participant describes their perception that the resource is a necessity, or otherwise provides a prerequisite to some aspect of their graduate program. | [ <i>Academic stipend</i> ] Would not be feasible to complete my degree without this.                                | 59                              | 3.25%             |

Table 4.3 continued

| <i>Theme</i>  | <i>Code</i> | <i>Description</i>                                                                                                                      | <i>Example</i>                                                                                                                      | <i>Frequency (N=1816 codes)</i> | <i>Percentage</i> |
|---------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-------------------|
| Help Provided | Basic need  | Resources fulfills some aspect of participants' requirements of living or survival, including food, shelter, security, healthcare, etc. | [ <i>Academic stipend</i> ] To survive day-to-day and pay my bills. I need to pay rent and eat.                                     | 236                             | 13.0%             |
|               | Connection  | Resource links the participant to other resources                                                                                       | [ <i>Advisor</i> ] My advisor can connect me with the resources I need but don't know about                                         | 77                              | 4.24%             |
|               | Academic    | Resource helps student with some aspect of their academic endeavors – including research or degree progress and career pursuits         | [ <i>Electronic resources (e.g., specific research software, R, mendeley)</i> ] Could not explore and analyze my data without them. | 585                             | 32.21%            |
|               | Persistence | Resource motivates or otherwise provides affective assistance in student retention in their program                                     | [ <i>Other graduate students</i> ] My motivation to finish comes from my peers                                                      | 78                              | 4.30%             |
|               | Support     | Resource provides student with some sort of mentoring, guidance, or help with problem solving                                           | [ <i>Advisor</i> ] Overall guidance through the process of my graduate education.                                                   | 459                             | 25.28%            |
|               | Wellbeing   | Resource supports students' emotional health by reducing stress, offering community, or providing emotional support                     | [ <i>Friends</i> ] Friends help to maintain work-life balance and have a life outside of work                                       | 267                             | 14.70%            |

Table 4.4: Code prevalence (percent of total codes for each demographic group) across demographic categories for participants' top three most frequently selected resources.

| <i>Code</i>    | <i>First / Continuing generation</i> | <i>Nonwhite / White</i> | <i>Woman / Man</i> | <i>Years 1-2 / Years 3+</i> |
|----------------|--------------------------------------|-------------------------|--------------------|-----------------------------|
| <i>Advisor</i> |                                      |                         |                    |                             |
| Academic       | 25.88 / 23.61                        | 28.28 / 23.80           | 24.65 / 24.32      | 26.81 / 23.57               |



Table 4.4 continued

| <b>Code</b>              | <i>First / Continuing generation</i> | <i>Nonwhite / White</i> | <i>Woman / Man</i> | <i>Years 1-2 / Years 3+</i> |
|--------------------------|--------------------------------------|-------------------------|--------------------|-----------------------------|
| Availability             | 3.53 / 3.43                          | 3.45 / 3.40             | 3.36 / 2.70        | 2.98 / 3.80                 |
| Basic need               | 0.39 / 0                             | 0 / 0.28                | 0.28 / 0           | 0 / 0.38                    |
| Connection               | 5.49 / 4.72                          | 4.14 / 5.67             | 5.60 / 4.50        | 3.40 / 6.84                 |
| Support                  | 43.92 / 48.50                        | 42.07 / 47.03           | 44.54 / 52.25      | 45.96 / 45.52               |
| Essential                | 0.78 0.86                            | 0.69 / 0.85             | 0.56 / 0           | 0 / 1.52                    |
| Persistence              | 8.24 / 7.30                          | 8.97 / 7.08             | 8.68 / 4.50        | 7.23 / 7.98                 |
| Validity                 | 7.84 / 9.01                          | 8.28 / 9.07             | 8.96 / 9.91        | 8.51 / 9.13                 |
| Well being               | 3.92 / 2.58                          | 4.14 / 2.83             | 3.36 / 1.8         | 5.11 / 1.52                 |
| <i>Stipend</i>           |                                      |                         |                    |                             |
| Academic                 | 20.25/16.67                          | 13.51/20.26             | 15.86 / 27.87      | 15.83 / 20.96               |
| Availability             | 0                                    | 0                       | 0                  | 0                           |
| Basic need               | 60.74 / 63.04                        | 71.62 / 58.62           | 63 / 59.02         | 62.59 / 61.08               |
| Connection               | 0.61 / 0                             | 0 / 0.43                | 0.44 / 0           | 0.72 / 0                    |
| Support                  | 0                                    | 0                       | 0                  | 0                           |
| Essential                | 12.27 / 17.39                        | 13.51 / 15.09           | 15.86 / 11.48      | 15.83 / 13.77               |
| Persistence              | 0.61 / 0                             | 0 / 0.43                | 0.44 / 0           | 0.72 / 0                    |
| Validity                 | 0.61 / 0                             | 0 / 0.43                | 0.44 / 0           | 0.72 / 0                    |
| Well being               | 4.91 / 2.90                          | 1.35 / 4.74             | 3.96 / 1.64        | 3.60 / 4.19                 |
| <i>Significant other</i> |                                      |                         |                    |                             |
| Academic                 | 6.58 / 9.59                          | 8.16 / 7.84             | *Women only 6.96   | 5.97 / 9.52                 |
| Availability             | 1.32 / 0                             | 2.04 / 0                | *Women only 0      | 0 / 1.19                    |
| Basic need               | 0 / 4.11                             | 0 / 2.94                | *Women only 2.61   | 1.49 / 2.38                 |

Table 4.4 continued

| <b>Code</b>                     | <i>First / Continuing generation</i> | <i>Nonwhite / White</i> | <i>Woman / Man</i> | <i>Years 1-2 / Years 3+</i> |
|---------------------------------|--------------------------------------|-------------------------|--------------------|-----------------------------|
| Connection                      | 0                                    | 0                       | *Women only 0      | 0                           |
| Support                         | 31.58 / 38.36                        | 30.61 / 37.25           | *Women only 34.78  | 31.34 / 38.10               |
| Essential                       | 0                                    | 0                       | *Women only 0      | 0                           |
| Persistence                     | 9.21 / 6.85                          | 10.2 / 6.86             | *Women only 8.70   | 10.45 / 5.95                |
| Validity                        | 0                                    | 0                       | *Women only 0      | 0                           |
| Well being                      | 51.32 / 41.10                        | 48.98 / 45.10           | *Women only 46.96  | 50.75 / 42.86               |
| <i>Online academic journals</i> |                                      |                         |                    |                             |
| Academic                        |                                      |                         | *Men only 72.73    |                             |
| Availability                    |                                      |                         | *Men only 0        |                             |
| Basic need                      |                                      |                         | *Men only 0        |                             |
| Connection                      |                                      |                         | *Men only 18.18    |                             |
| Support                         |                                      |                         | *Men only 4.55     |                             |
| Essential                       |                                      |                         | *Men only 4.55     |                             |
| Persistence                     |                                      |                         | *Men only 0        |                             |
| Validity                        |                                      |                         | *Men only 0        |                             |
| Well being                      |                                      |                         | *Men only 0        |                             |

## CONCLUSION

The four chapters of this dissertation shed light on the factors that impact graduate student success in STEM higher education, particularly for minoritized students. In the first chapter, I argued that focusing solely on academic definitions of success impede the real success of our students; and indeed, this claim was supported by the findings of chapter two, which revealed that students' felt anxious, stressed, and ashamed to hold definitions of success that were not solely academic. These students were picking up on the hegemonic narratives that dominate academia – compete with your peers, publish or perish, you need to do X or you won't get a job, and so on. Many students in this study expressed their opposition to these narratives and detailed how, over time and with the guidance of supportive mentors, their definitions of success evolved, becoming broader and incorporating both academic and non-academic components. In the same way we know that diverse ecosystems are more resilient to change, it may be that these broad, diverse definitions of success may be more resilient to the challenges and issues that students face during their graduate programs. Overall, these chapters revealed that prevailing knowledge had a relatively narrow view of student success, and by adding student voice to the literature, this definition is now much broader, and these broad, diverse definitions are likely to help how mentors and institutions interact with and support their students.

I found a similar pattern in terms of student resource use, where prevailing literature had a relatively narrow view of student resource use, and by adding student voice, I discovered that far more nuance was present, and I suggest that validating this nuance will help better support graduate students. Historically, education research has examined student resource use on a resource-by-resource basis. For example, many studies have examined the impact of graduate students' mentors, or the impact of graduate students' access to healthcare. While these studies are important and have advanced the field, few studies represent the reality of the student experience; students currently exist in a world full of resources, from access to everything online, to resources provided by universities, to unprecedented access to other academics and friends on social media. By studying single resources, it's likely that previous studies have missed details and nuance that emerge from the complexities of students' resource-laden academic lives. Thus, the third chapter of my dissertation used a national survey to explore life science graduate students' use and perception of 34 resources. Results revealed the importance of students' academic stipend, which was used most frequently and perceived as most useful, highlighting the importance of academic support for graduate students, a point which is not often discussed in prevailing literature. Results from this chapter, and the importance of academic stipend specifically, suggested that students' resource use may be driven by students' needs, similar to the ideas posited by Maslow in his infamous Theory of Human Motivation (1949). Thus, I followed up this study with a qualitative exploration of student perceptions of resource value (i.e., why do students think resources are important). Results from this study echoed Maslow's theory, participants expressed that they valued resources because of what they resource did for them; students' academic stipend was important because it allowed them to pay rent, advisors were important because they provided valuable academic feedback, and so on. I used these results to propose a model for understanding graduate student resource choice, 'The Academic Hierarchy of Needs,' that may be used to inform future research and mentoring.

Finally, chapters three and four provided conflicting results about the importance of demographic characteristics. In chapter three, I found a significant relationship between certain

demographic characteristics and students' use and perception of resources. For example, race (i.e., nonwhite versus white) significantly predicted students' use of 13 of 34 resources, and their perception of value of 10 of 34 resources. However, in chapter 4, I found no significant relationship between student demographic characteristics and their perception of resource value. It may be that student demographic characteristics drive their resource outcomes (i.e., use and perception of value), but that these only play a significant role at the margins; it may be that the most important resources (chapter 4) are important for the same reasons, regardless of student demographic characteristics. However, other explanations abound, and future work should investigate these discrepancies.

Overall, this work underscores the importance of student perspectives—in their resource use, in their perception of value, in their definitions of success, and in their experiences broadly. Students are not, and never have been a monolith, and policies and practices within higher education must reflect this. Based on the findings herein, it is recommended that institutions and researchers in science education engage in self-reflection and institutional change to redefine success in a more inclusive and equitable way. By broadening definitions of success to reflect those of the student population, institutions may begin to value resources in a way that is more aligned with student perspectives. For example, when success is not defined solely as the pursuit of academic achievement, resources like family and community become more than incidentals on the road toward success, instead they may instead be considered as essential to maintaining well-being, creating balance, and living a more fulfilling life. A change in institutional value structure, then, may help to address extant issues in graduate student mental health, attrition, and may facilitate a healthier, happier, and more productive population of graduate students.

There are many recommendations throughout this thesis, but if there's only one that readers apply, let it be this—one of the most effective ways we can improve graduate education is by simply talking to our graduate students. By doing so, we learn that each of our graduate students is a unique individual with their own needs, definitions of success, and plans for how to get there. Conversations like these are the first step in re-creating graduate programs that are responsive to the needs of its students and truly foster success.

## **FUTURE WORK**

As with all good science, this research has only created more questions. Future work should investigate how students learn about the resources they use and how that may affect student perceptions of resource value. Furthermore, far more work is needed to understand the complexities that likely exist between resource use, student characteristics, and academic outcomes. I predict that resource use may play a key mediation role in the relationship between student characteristics and academic outcome, and I am especially interested in how this relationship may change over time. More qualitative work is always needed, and that is especially true in the realm of student resource use; future work may consider investigating the potential theoretical overlap between expectations and values. Furthermore, I am especially interested in qualitative examination of how resource use changes over time and as graduate students overcome hurdles in their program – understanding students' experiences related to these hurdles may help mentors, graduate programs, and institutions to guide students towards adaptive resource use (e.g., leaning on social support networks), preempting student attrition and facilitating student success.

## VITA

Maryrose Weatherton grew up in the suburbs of Chicago and attended Marquette University in Milwaukee, Wisconsin, where she graduated in 2018 with a bachelor's degree in Biological Sciences and found her passion for ecology and education. She joined the University of Tennessee in 2019 and began working toward answering a burning question, 'how does resource access and use influence community composition?' While at the University of Tennessee, Maryrose published multiple papers and engaged in many collaborations. Following her passion for education and service, Maryrose was also heavily involved in departmental mentoring and leadership, including a two-year term as president of the Graduate Researchers in Evolutionary Biology and Ecology (GREBE) student body, three years as a coordinator for the EEB Mentoring Program, and more. In 2020, Maryrose received a National Science Foundation Graduate Research Fellowship to pursue her graduate dissertation and throughout her graduate career, she has received more than \$140,000 in funding. Maryrose will receive her PhD in Ecology and Evolutionary Biology in May of 2023, after which she will continue to pursue her research interests in a post-doctoral position.