Examining teaching and research anxieties, self-efficacy, and coping in Biology Graduate Teaching Assistants (GTAs): a snapshot of graduate student mental health

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DEDICATION

For the Glory of God.

“I have been crucified with Christ, and the life I live now is not my own; Christ is living in me.”
Galatians 2:19

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ABSTRACT

Graduate students report increasing levels of anxiety and depression compared to the general public, negatively impacting their overall mental health and degree attainment in graduate programs. Yet we are only beginning to understand what contributes to graduate student anxiety. Biology Graduate Teaching Assistants (GTAs) in particular occupy an “ambiguous niche” in academia with simultaneous roles as teachers, researchers, students, and employees. Balancing these roles can contribute to anxieties, particularly in regard to teaching and research responsibilities. My dissertation investigated Biology GTA anxieties related to teaching and research roles, how these anxieties change over time, how GTAs cope with these emotions, and how career aspirations relate to these anxieties. I surveyed (n=89) and interviewed (n=23) Biology GTAs at a research-intensive university twice over one year. Results revealed that a GTA’s teaching self-efficacy is an important predictor of teaching anxiety, with greater self-efficacy related to decreased anxiety. Interviews revealed that five factors were associated with teaching and research anxieties, but in different proportions for each role. Anxiety related to a lack of self-efficacy was most common for research roles; while anxiety related to impact on others (e.g. students) was more prevalent in teaching roles. Anxieties related to role tensions or time constraints between teaching and research also arose, though GTAs with academic career aspirations expressed these anxieties less compared to GTAs with non-academic career goals. Lastly, when examining how GTAs coped with teaching and research anxieties, GTAs overall tended to use adaptive coping strategies, despite differences between roles. Problem solving and information seeking were used in both teaching and research contexts; but support

seeking strategies were used more often in research. Over time, the use of these adaptive coping strategies declined among GTAs, however, maladaptive strategies did not notably increase. This may indicate a stabilization of coping strategies over time. Given the important roles that GTAs play as instructors in introductory Biology and in the production of research at research-intensive institutions, it is important to understand how GTAs are experiencing anxieties related to teaching and research roles in order to better support their mental health through institutional resources to manage such stressors.

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INTRODUCTION

The incidence of anxiety in graduate students in the United States has been rising markedly over the last several decades (Bair and Haworth 2004). One in three graduate students in the United States report being depressed, a rate six times higher than the general public (T. M. Evans et al. 2018). Anxiety affects not only the overall mental well-being of graduate students, but also reduces their retention in graduate programs (Bair and Haworth 2004; Kinman 2001; UC Berkeley Graduate Assembly 2014). Anxiety is defined as the state of anticipatory apprehension over possible deleterious happenings (Bandura 1988). It can stimulate physiological responses similar to stress: increased levels of cortisol, faster heartrate, dilated pupils, etc. However, these physical changes accompany feelings of concern or worry over an anticipated event or outcome that may happen in the future (Pekrun et al. 2007). Despite these and many other reports of mental health issues in graduate students, we are only beginning to understand the contributing factors to graduate student mental health.

Our current understanding of the causes of graduate student mental health issues, such as anxiety, are wide ranging—lack of advisor support, lack of social support, poor perception of employment prospects, or family/monetary concerns, to name a few (Devos et al. 2017; Golde 2005; Hish et al. 2019; Levecque et al. 2017; Mousavi et al. 2018). Despite the growing number of studies that attempt to pinpoint the causes of graduate student mental health issues, one issue that has been relatively unexplored is how balancing multiple roles as a graduate student may exacerbate anxieties (Lane, Hardison, et al. 2019).

Graduate students often assume multiple roles (e.g., teacher, researcher, employee, student) at their institutions (Jenkins 2004). During socialization into their graduate program graduate students must strike a balance between these roles; for Graduate Teaching Assistants (GTAs) this is particularly important for teaching and research responsibilities. Biology GTAs teach over 91% of freshman Biology labs and discussions nationally, making them important determinants of the quality of undergraduate education (Sundberg, Armstrong, and Wischusen 2005). Graduate students' research productivity is also critical to the successful functioning of large, research-driven universities (National Academies of Sciences Engineering and Medicine 2018). Given these important dual roles as instructors and scholars-in-training, it is important to understand how GTAs are experiencing anxieties related to teaching and research to help them best manage such stressors.

What is teaching anxiety and research anxiety?

Graduate students often find themselves teaching with little to no pedagogical professional development (Gardner and Jones 2011; Prieto and Scheel 2008), all while establishing research projects and navigating departmental cultures. As a result, GTAs may experience a lack of confidence about their teaching (Pelton 2014; Prieto and Altmaier 1994; Reeves et al. 2018), resulting in teaching anxiety. Based on the definition of anxiety, teaching anxiety would be a feeling of concern that their teaching will not go well because they do not have the teaching resources to meet the demands of the task. This is of concern institutionally because teaching anxiety has been linked with lower instructional quality (YoonJung Cho et al. 2011; Coates and Thoresen 1976). Many studies have been conducted on teaching anxiety (Parsons 1973; Pelton 2014; K.

D. Roach 2003), often in association with professional development programs to improve instruction abilities.

While teaching anxiety has been studied more often, there are few studies which explicitly investigate graduate student research anxiety. Once again, this anxiety would be based on a graduate student feeling that they could not meet the prospective demands of research because of a lack of personal resources or abilities. Institutions not only rely on graduate students' teaching for large enrollment course, but also rely on their successful research output (National Academies of Sciences Engineering and Medicine 2018). Their productivity also determines their career prospects, particularly if graduate students aim to pursue increasingly competitive academic appointments (Larson, Ghaffarzadegan, and Xue 2014). Because of the pressure to produce research, and the implicit or explicit assumption that research is more important than teaching, graduate students also can experience the tension between teaching and research roles. This can be exacerbated by a graduate students' personal career goals which may be focused on research or teaching or both (Connolly, Lee, and Savoy 2018; Fuhrmann et al. 2011). How these varied career goals interact with teaching and research anxieties is relatively unexplored in the literature.

Building self-efficacy and coping may be critical to managing anxiety

Bandura's social cognitive theory, particularly pertaining to self-efficacy, is an important conceptual framework for studying anxiety in GTAs. Social cognitive theory explains how an individual's behavior can be shaped by personal, behavioral, and environmental influences (Bandura 1986). A central concept in social cognitive theory is *self-efficacy*. Self-efficacy is the belief or confidence in one's ability to successfully carry

out a specific task or course of action (Bandura 1988; Lent, Brown, and Hackett 2000). Self-efficacy has been widely studied within psychology, and more recently applied to GTA teaching (Connolly et al. 2016; DeChenne et al. 2015; DeChenne, Enochs, and Needham 2012; Reeves et al. 2016). In the college setting, high teaching self-efficacy in GTAs correlates with strong performance in teaching (DeChenne et al. 2015). Variables such as previous teaching experience, perceived quality of GTA teaching professional development (TPD), total hours of TPD, and perception of the departmental climate are significant factors that impact teaching self-efficacy of STEM GTAs (DeChenne et al. 2015). Other studies suggest that participating in TPD significantly increases teaching self-efficacy in GTAs, particularly for women (Connolly, Lee, and Savoy 2018; Reeves et al. 2018). Therefore, in light of this framework, we predict GTAs with high teaching self-efficacy will have lower teaching anxiety.

Another factor related to anxiety is coping. Coping can be defined as an individual's behavioral response(s) to external stressors, often with the objective to reduce or tolerate the stress (Carver, Scheier, and Weintraub 1989; Henry et al. 2019; Lazarus 1993; Shin et al. 2014; Skinner et al. 2003). Roach (2003) described coping as "trying to find some way to deal with or address [felt] needs or problems." Coping can be conceptualized as either (1) *adaptive* or (2) *maladaptive* (Henry et al. 2019). Adaptive coping helps to advance individuals through problems and support their well-being (e.g. seeking social support, practicing before giving a lecture); while maladaptive coping prevents stressors or problems from being resolved and can exacerbate threats to well-being (e.g. social withdrawal, avoid writing tasks). Coping varies with the stressor, and some situations can involve both adaptive and maladaptive coping (e.g. returning to

writing tasks after initial avoidance). With Biology GTAs balancing multiple roles as teachers, researchers, students, and employees, those with anxiety need effective coping strategies. We predict that greater frequency of coping and use of adaptive coping strategies should lead to lower anxiety. Those with higher anxiety may not cope or may not be using adaptive coping strategies. Within the GTA literature, there has been little research examining coping type and frequency in relation to anxiety.

We posit that self-efficacy and coping are critical variables to help mitigate teaching and research anxiety in graduate students. For example, if a GTA struggles with research anxieties related to disappointing their advisor in their writing, GTAs may want to build research self-efficacy, particularly practicing their writing skills, and thus use problem solving coping strategies to mitigate anxieties. By understanding graduate student anxiety in general, and in regard to their teaching and research, we can support better undergraduate education and the mental health of graduate students.

Using Social Cognitive Career Theory (SCCT) as a theoretical framework

Social Cognitive Career Theory (SCCT) provides an appropriate theoretical framework to guide the research questions being pursued in this dissertation. The SCCT was developed to identify the cognitive variables (e.g. self-efficacy), behavioral (e.g. career choice), and contextual (e.g. past learning experiences) which influence a person's career interests and trajectory (Lent et al. 1994). For the dissertation, I added variables of anxiety and coping to the existing SCCT model, guided by literature on the relationships between self-efficacy, anxiety, and coping (Figure 1). I predict that teaching and research anxiety relates to GTA self-efficacy (e.g. "Can I teach well?") and outcome expectations (e.g. "What will happen if I do teach poorly?") towards teaching or

research tasks. A GTA's ability to cope (adaptive or maladaptive) with teaching and research anxieties would further impact performance in these contexts, helping or hindering GTAs from progressing through stressors, subsequently influencing the formation of their career interests and choices. Thus, anxiety, self-efficacy, and coping would all be interrelated and related to future career interests such as academic or non-academic paths.

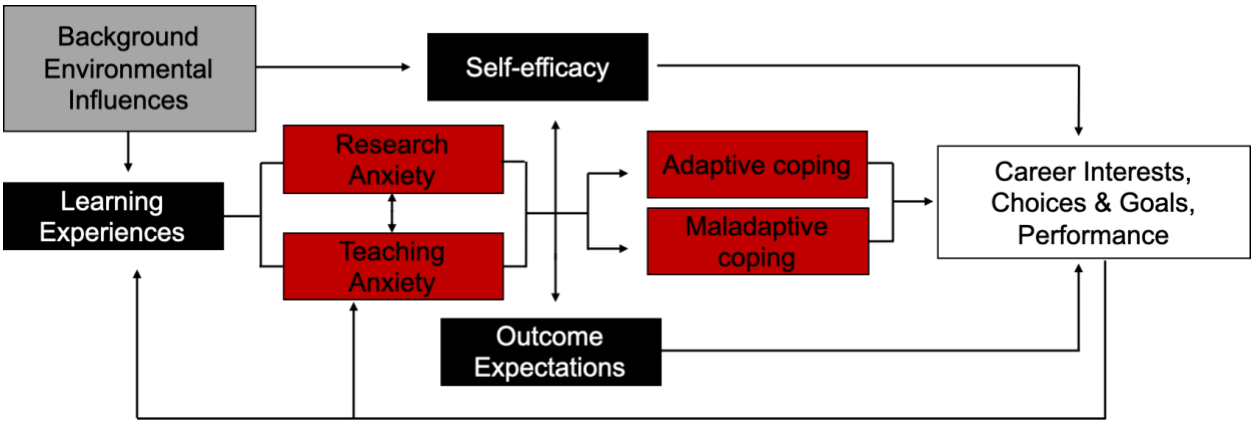


Figure 1. Modified theoretical model from the Social Cognitive Career Theory (SCCT), specifically for careers that are geared towards academic or non-academic goals. The SCCT aims to understand the multiple components which contribute to how career interests, choices, and goals develop. The grey box indicates influencing background or contextual components, the white box indicates the career outcomes such as academic or non-academic aspirations, and the black boxes are the main drivers that contribute to career development. Additional components of anxiety and coping can be found in red boxes. Teaching and research anxiety would impact self-efficacy and outcome expectations, which are strengthened or weakened as a result of learning experiences. The strength of a GTA's coping would then determine how a GTA progressed towards career goals and performance, and also impact how much anxiety would influence self-efficacy and outcome expectations.

Dissertation Chapters and Research Questions

This dissertation investigates three overarching questions related to teaching anxiety, research anxiety, self-efficacy, and coping in Biology GTAs at a large research-intensive university. It will address the following major research questions in each of three chapters of my dissertation:

1. What factors impact GTA teaching anxiety?
2. How do GTA teaching and research anxieties compare?
3. How do GTAs cope with teaching and research anxieties?

Using multiple validated surveys, the first chapter quantitatively explores the relationship between teaching anxiety, self-efficacy, and coping among Biology GTAs. Anxiety specifically associated with teaching negatively impacts student learning (Marso and Pigge 1998; K. D. Roach 2003), yet the levels of teaching anxiety Biology GTAs experience, and factors which may contribute to this anxiety are not well-known. In Fall 2016, we surveyed 89 Biology GTAs about their teaching anxiety, teaching self-efficacy, coping, and other contextual and demographic variables to statistically model what impacts teaching anxiety. These quantitative measures revealed interesting relationships, however, they were not able to fully capture the experience of GTA teaching anxieties and there were no existing instruments to measure research anxiety. Thus, in my second chapter, I examined the experiences of GTAs and their teaching and research anxieties.

The second chapter of my dissertation qualitatively explores anxieties expressed by Biology GTAs related to their teaching and research roles. GTAs occupy an "ambiguous niche" in academia with simultaneous roles as teachers, researchers, students, and employees. Tensions between these roles can contribute to anxieties

related to teaching and research responsibilities. To explore GTA teaching and research anxieties, I interviewed the same 23 Biology GTAs at a research-intensive southeastern university twice, once in 2016 and once in 2017. Open coding of semi-structured interviews revealed five major themes of GTA anxieties related to teaching and research roles, how these anxieties changed over time, and how career aspirations related to these anxieties.

Lastly, the third chapter of my dissertation qualitatively examined how Biology GTAs coped with anxieties related to teaching and research. I predicted that differences in coping may be attributed to differences based on teaching and research contexts, in socialization of graduate students in their programs over time, and differences in career aspirations. In the same interviews that captured teaching and research anxieties, I also asked Biology GTAs about their coping strategies to these anxieties. In understanding how GTAs cope with teaching and research anxieties over time and in relation to different career goals, this work can inform future professional development for GTAs, support adaptive coping strategies, and encourage greater awareness and dialogue about the impacts of GTA mental health issues in academia.

CHAPTER I

ANXIOUS ACADEMICS: EXAMINING TEACHING ANXIETY IN BIOLOGY GRADUATE TEACHING ASSISTANTS (GTAS)

A version of this chapter has been submitted for publication to the *International Journal of STEM Education* by Miranda Chen Musgrove and Elisabeth E. Schussler:

The first author contributed to the research concept, data collection, data analysis, and manuscript writing. The second author contributed to the research concept and manuscript writing.

Abstract

Anxiety among graduate students in the United States has increased over the last several decades, affecting not only their overall mental health but also reducing retention in graduate programs. High teaching anxiety of teachers can negatively impact teacher well-being and student learning, yet teaching anxiety in graduate teaching assistants (GTAs) is not well studied. Biology GTAs teach most introductory Biology labs and discussions nationally, thus broadly influencing the quality of undergraduate Biology education. In Fall 2016, we surveyed Biology GTAs at a large research-intensive university to (1) measure their self-reported teaching anxiety, self-efficacy, and coping, and (2) explore how teaching self-efficacy and coping related to teaching anxiety. There was a normal distribution of teaching anxiety levels in the 89 GTA participants, with only some GTAs having very low and high anxiety. GTAs often had high perceptions of their teaching self-efficacy, while coping frequencies ranged in use depending on the strategy. Using correlation plots and multiple linear regressions, we found that greater teaching self-efficacy was related to lower teaching anxiety in Biology GTAs (R_{2adj}=0.67, p<0.001), and coping was not directly related to teaching anxiety. However, correlations revealed that coping was positively correlated to self-efficacy. This suggests that high teaching self-efficacy may be important to reducing teaching anxiety, and increased coping frequency may increase teaching self-efficacy. Thus, coping may be indirectly linked to anxiety, while self-efficacy is directly linked, although these specific relationships need to be further explored. In the sample of Biology GTAs we examined, increasing teaching self-efficacy may be an effective tool for decreasing teaching anxiety. With a rising mental health crisis in academia, particularly among

graduate students, these results can inform teaching professional development for GTAs, especially incorporating dialogue about teaching anxiety, self-efficacy, and coping. By explicitly discussing these mental health issues in academia, we can hopefully reduce teaching anxiety and support positive GTA outcomes on undergraduate teaching quality.

Introduction

Research universities depend on graduate students for instruction, especially for large enrollment classes (Gardner and Jones 2011; Sundberg, Armstrong, and Wischusen 2005). Biology graduate teaching assistants (GTAs) have been estimated to teach over 91% of freshman Biology labs and discussions nationally (Gardner and Jones 2011; Prieto and Scheel 2008; Sundberg, Armstrong, and Wischusen 2005). According to the Longitudinal Study of Future STEM Scholars (LSFSS, Connolly et al. 2016), which studied more than 3,000 STEM PhD students over 4 years, nearly all (94.9%) taught undergraduates during their doctoral programs. These graduate students, however, often teach with little to no pedagogical training (Schussler et al. 2015). Given university reliance on GTAs for teaching, factors that decrease instructional quality may greatly influence the quality of undergraduate education at the institution.

One factor known to decrease instructional quality is teaching anxiety (Hadley and Dorward 2011; Hagenauer, Hascher, and Volet 2015; Marso and Pigge 1998). Anxiety is defined as the state of anticipatory apprehension over possible deleterious happenings (Bandura 1988). It arises when the individual does not feel they have the

resources to address the challenge at hand (Bandura 1988). Anxiety stimulates physiological responses similar to stress: increased levels of cortisol, faster heartrate, dilated pupils, etc. However, these physical changes accompany feelings of concern or worry over an anticipated event or outcome that may happen in the future (Pekrun et al. 2007). By these definitions, teaching anxiety is an unpleasant feeling about what may happen during teaching because of a lack of personal resources to meet this challenge. Given this, GTAs may be more prone to teaching anxiety because of their lack of teaching professional development (Pelton 2014; Reeves et al. 2018). Indeed, multiple studies have documented a lack of graduate student confidence (Prieto and Altmaier 1994) or anxiety (Reeves et al. 2018) in regard to their teaching.

This specific anxiety about teaching occurs within a context of rising anxieties about graduate study overall. The reported incidence of anxiety in graduate students in the United States has been rising markedly over the last several decades (Bair and Haworth 2004; T. M. Evans et al. 2018; Levecque et al. 2017; Nagy et al. 2019). Graduate students in the United States are six times more likely to experience depression and anxiety than the general public (T. M. Evans et al. 2018; Levecque et al. 2017). This epidemic of anxiety is associated with rises in graduate student attrition from graduate programs (e.g. Bair and Haworth 2004; Chakraverty 2019), visits to institutional mental health providers (e.g. Levecque et al. 2017), and general concerns about graduate student well-being (e.g. Nagy et al. 2019; Sverdlik and Hall 2019). Thus, concerns about teaching anxiety in GTAs is tightly associated with a myriad of other mental health concerns that may impact the success of these graduate students.

This study focuses specifically on Biology GTA anxieties related to teaching because of the broad importance of these roles to undergraduate instructional quality, particularly for introductory courses where undergraduate attrition from the major can be high (Chen and Soldner 2013). There has been little research on the causes and consequences of teaching anxiety among GTAs, making it difficult to assess or address these concerns. In this study, we explore the teaching anxiety levels of a sample of GTAs at one research institution as well as two factors that may relate to teaching anxiety: teaching self-efficacy and coping. There are theoretical relationships among anxiety, self-efficacy, and coping (Bandura 1988) that we test in our population, along with potential demographic and background/contextual influences on these constructs. Previous studies have investigated GTAs' teaching self-efficacy (DeChenne et al. 2015; DeChenne, Enochs, and Needham 2012), graduate student coping with writing (Carter-Veale et al. 2016), and GTA coping with teaching apprehension (K. D. Roach 2003). To our knowledge, this study is the first to examine Biology GTA teaching anxiety, teaching self-efficacy, and coping under one model.

Anxiety and self-efficacy

Bandura's social cognitive theory, particularly pertaining to self-efficacy, provides a useful theoretical framework for studying anxiety in GTAs. Social cognitive theory explains how an individual's behavior can be shaped by personal, behavioral, and environmental influences (Bandura and Cliffs 1986). A central concept in social cognitive theory is *self-efficacy*. Self-efficacy is the belief or confidence in one's ability to successfully carry out a specific task or course of action (Bandura 1988; Lent, Brown,

and Hackett 2000). Self-efficacy has been widely studied within psychology, and more recently within GTAs (Connolly et al. 2016; DeChenne et al. 2015; DeChenne, Enochs, and Needham 2012; Reeves et al. 2018). In this study, we will be focusing on self-efficacy as it relates to teaching.

According to Tschannen-Moran, Hoy, and Hoy (1998), *teaching self-efficacy*, specifically, is a teacher's perception of their ability to "organize and execute courses of action required to successfully accomplish a specific teaching task in a particular context." Teachers with stronger teaching self-efficacy beliefs often have more efficient classroom management, planning and organization, demonstrate greater enthusiasm and commitment, a greater willingness to try new pedagogical methods, persist in difficult teaching-related tasks, and is predictive of positive student achievement (Klassen and Usher 2010; Pajares 2008; Usher and Pajares 2009; Woolfork Hoy 2003). Self-efficacy is a strong predictor of success in a task. Self-efficacy has been described as having a negative relationship with anxiety; with greater self-efficacy towards a particular task, there is less anxiety towards said task (Bandura 1988).

There are four main mechanisms that build self-efficacy: 1) mastery experiences, 2) vicarious experiences, 3) social persuasion, and 4) emotional/physiological appraisal (Bandura 1993). For example, a GTA with many years of teaching experience has likely gained high teaching self-efficacy through mastery experiences. As a novice teacher, she may have observed experienced GTAs teach—an example of building teaching self-efficacy vicariously. To improve self-efficacy through social persuasion, a GTA could be convinced by her mentor or trusted friend that she would be a successful teacher. Lastly, cognitive appraisals lead to positive or negative emotions that can alter

individuals' beliefs about their capabilities (Bandura 1988, 1993). For example, a GTA who is worried about teaching well may interpret these feelings as a sign of poor future performance, and thus may have low teaching self-efficacy. All four mechanisms of building self-efficacy depend on the individuals' cognitive processing related to the specific task, the context of said task, and self-assessment of task competence.

In the college setting, high teaching self-efficacy in GTAs correlates with strong performance in teaching (DeChenne et al. 2015). DeChenne et al. (2012) identified two major constructs within teaching self-efficacy in STEM GTAs: *learning environment self-efficacy* and *instructional self-efficacy. Learning environment self-efficacy* is related to a teacher's belief in being able to promote a positive learning environment via student participation, while a teacher's *instructional self-efficacy* is related to their confidence in being able to carry out "instructional tasks," e.g. clearly identify learning objectives, grading, preparedness to teach, etc. Structural equation models to predict STEM GTAs' self-efficacy found that variables such as previous teaching experience, perceived quality of GTA teaching professional development (TPD), total hours of TPD, and perception of the departmental climate were significant factors that impacted these teaching self-efficacy constructs (DeChenne et al. 2015). Other studies suggest that participating in TPD significantly increases teaching self-efficacy in GTAs, particularly for women (Connolly, Lee, and Savoy 2018; Reeves et al. 2018).

Given this literature, we predict that GTAs in our study who have higher teaching self-efficacy will have lower teaching anxiety. Although we are not testing these relationships, the literature also suggests that teaching experience, observing others

teach, peer and advisor mentoring, and effective TPD would be factors to build self-efficacy.

Anxiety and coping

Another factor related to anxiety is coping. Coping can be defined as an individual's behavioral response(s) to external stressors, often with the objective to reduce or tolerate the stress (Carver, Scheier, and Weintraub 1989; Henry et al. 2019; Lazarus 1993; Shin et al. 2014; Skinner et al. 2003). Roach (2003) described coping as "trying to find some way to deal with or address [felt] needs or problems." Coping can be conceptualized as either (1) *adaptive* or (2) *maladaptive* (Henry et al. 2019; Skinner et al. 2003). Adaptive coping is often needed when individuals approach the stressor, and employ strategies which helps them to advance through their problems and support their well-being (e.g. practice for a presentation, seek social support); while maladaptive coping prevents stressors or problems from being resolved and can exacerbate threats to well-being (e.g. avoid writing tasks, social withdrawal). Coping varies with the stressor, and some situations can involve both adaptive and maladaptive coping (e.g. returning to writing tasks after initial avoidance).

Biology GTAs balance multiple roles as teachers, researchers, students, and employees, so those with anxiety need effective coping strategies. Roach (2003) examined how 6 different types of coping strategies among 121 new GTAs related to teaching anxiety and found positive correlative relationships between the use of coping and anxiety (those with more anxiety coped more frequently). Thus, we predict that individuals with higher teaching anxiety will need to cope more frequently; and those

with lower teaching anxiety may not need to use coping strategies as frequently. The goal of coping is to ultimately reduce anxiety, suggesting that greater frequency of coping and use of effective coping strategies should eventually lead to lower anxiety. This can make it hard to establish definitive relationships between the two, because someone may employ high coping to ultimately have low anxiety. Within the science GTA literature, there has been little research examining coping efficacy and frequency in relation to anxiety.

Self-efficacy and coping

Effective coping to a potential stressor or threat is theoretically related to increases in self-efficacy for a task, especially if there is anxiety towards it. Alongside the need to develop teaching self-efficacy to combat teaching anxieties, Bandura (1988) posits that coping can actually represent another task in which self-efficacy can be increased to reduce anxiety. As he describes: *"perceived self-inefficacy in coping with potential threats gives rise to fearful expectations and avoidance behavior"* (Bandura 1988). A GTA who has low self-efficacy towards teaching tasks and also low self-efficacy towards coping with anxieties related to such tasks, are likely to maintain their anxiety and enact maladaptive coping strategies. For example, a GTA who is anxious about speaking in front of the classroom, who does not believe they can do well speaking in class, and who does not believe they can cope well with this anxiety, may continue feeling anxious or turn to avoidance coping to get their mind off the anticipated teaching task. Though coping efficacy is not what we are measuring in this study, we

predict that enacting more frequent coping strategies will be related to higher self-efficacy for teaching in our GTA population.

Background influences: Demographics and Context

Anxiety is not homogenous in a population, and teaching anxiety is presumably not as well. Some groups of GTAs (e.g. experienced teachers) may have built higher self-efficacy through mastery experiences and thus have lower reported anxieties (T. M. Evans et al. 2018; George, Saclarides, and Lubienski 2018). Differential levels of anxiety are likely to be based on several factors, such as teaching experience level (Miller, Brickman, and Oliver 2014), gender (T. M. Evans et al. 2018), or student citizenship status or nationality (George, Saclarides, and Lubienski 2018). Because of this, teaching anxiety will likely differ between some graduate student sub-populations (such as genders, racial/ethnic groups, novice vs. experienced GTAs, international vs. domestic GTAs, etc.). For example, women and other minority groups suffer differential impacts of mental distress, with 43% and 41% of women in graduate school reporting anxiety and depression, respectively, compared to 34% and 35% of men (T. M. Evans et al. 2018). International students in the United States also report different academic challenges compared to their domestic counterparts, such as concern over program structure, career preparation, and alignment with career goals (George, Saclarides, and Lubienski 2018). International students who come into graduate programs in the United States without English as their first language may also have teaching anxiety related to communication in the classroom (K. D. Roach and Olaniran 2001) or differences in teaching self-efficacy compared to GTAs where English is their native tongue (Deacon,

Hajek, and Schulz 2017). When surveying psychology graduate students about their stressors and well-being in the program, El-Ghoroury et al. (2012) found that minority students were more likely to report discrimination as a stressor compared to White respondents. These differences in concerns and stressors between genders, ethnicities, and citizenship status, may further extend to differences in anxieties towards a similar task (i.e. teaching). When studying anxiety in any context, it is important to capture contextual and demographic variables that may account for differences in anxiety in certain subgroups of the study population.

Research questions

Given the importance of GTAs as university instructors and the potential for anxiety to negatively impact teaching quality, this study investigated graduate students' teaching anxiety in a sample of Biology GTAs at a large research-intensive university in Fall 2016. Based on the literature, we predict that teaching self-efficacy, coping strategies or frequencies, and demographic or contextual variables will contribute to a Biology GTA's teaching anxiety. Therefore, we collected and analyzed data to answer two research questions:

(1) What are the levels of teaching anxiety, teaching self-efficacy, and coping among Biology GTAs?

(2) How do GTA teaching self-efficacy, coping, and contextual variables (e.g. gender, ethnicity, citizenship status, teaching experience, GTA's general anxiety) predict teaching anxiety?

Our specific predictions are that positive teaching self-efficacy and effective use of coping strategies will reflect lower levels of teaching anxiety. We also predict that certain subgroups within our GTA population, particularly minority groups, may have higher levels of teaching anxiety compared to their counterparts. Exploring these questions will reveal how teaching anxiety may vary across a population of GTAs in one disciplinary area and potentially inform teaching professional development regarding teaching self-efficacy and effective coping strategies among GTAs.

Methods

Study Population

Biology GTAs at a large research-intensive southeastern university were the study population. The GTAs were recruited from across the Division of Biology via a listserv of graduate students from three departments—Ecology & Evolutionary Biology (EEB), Microbiology (Micro), Biochemistry & Cellular and Molecular Biology (BCMB)—and one program, Genome Science & Technology (GST). Of these, 211 graduate students were enrolled in a Master's or PhD program. As of Fall 2016, approximately 94% of graduate students were seeking PhDs, and 55% identified as female.

Data Collection

In Fall 2016, an online survey was created, approved by the Institutional Review Board (IRB-16-03235-XP), and deployed to Biology graduate students via the Qualtrics survey software (see **Appendix**). The e-mail recruited individuals who were either currently teaching or who had been a GTA previously. The survey was open for two

weeks at the end of October 2016. We chose mid-semester to avoid capturing anxieties related to the beginning of the semester and give GTAs time to acclimate to their multiple responsibilities that semester. To encourage participation in the survey, a small monetary compensation of $5 was offered to each responding graduate student.

Three validated instruments from the literature were included in the survey to measure teaching anxiety, teaching self-efficacy, and coping (DeChenne, Enochs, and Needham 2012; Parsons 1973; K. D. Roach 2003). There were a total of 103 questions (items) in the survey, with 29 measuring teaching anxiety (Parsons 1973), 18 measuring teaching self-efficacy (DeChenne, Enochs, and Needham 2012), and 24 measuring frequency of the enactment of coping strategies (K. D. Roach 2003) (see **Appendix** for complete survey).

Teaching anxiety was measured using Parson's 29-item survey (Parsons 1973), which was initially developed to measure teaching anxiety in preservice K-12 teachers. Though Parson's instrument was developed with one teaching population in mind, her instrument has been implemented in many other K-12 and college teacher populations with similar distributions of teaching anxiety across the scale (e.g. Marso and Pigge 1998; Pelton 2014; Williams 1991). Additionally, Parsons (1973) did an extensive content validation of the original survey including observations from teaching supervisors and correlations with other anxiety scales. We did not define the term anxiety at the beginning of the survey because none of the survey items used the word "anxiety", but instead tried to capture and reflect experiences of "feeling concerned, worried, or anxious".

The survey was adapted for our study population (GTAs) by changing verbiage addressing “preservice teachers” to “GTAs”. Participants rated each statement on a 1-5 Likert scale, where 1 was “Never” and 5 was “Always”. For example, one item states, “I feel secure with regard to my ability to keep a class under control.” Other items probed GTAs’ feelings about having control in the classroom, answering student questions, comparing one’s abilities to others’ teaching, etc.

Self-efficacy was measured using DeChenne et al.’s self-efficacy survey (DeChenne, Enochs, and Needham 2012), which was developed with a GTA population at another institution. The survey is an 18-item instrument and items are rated on a 1-5 Likert scale, with 1 being “Not confident at all” and 5 being “Very confident” (DeChenne, Enochs, and Needham 2012). Two constructs of teaching self-efficacy were measured via this survey: *learning environment self-efficacy* (11 items) and *instructional self-efficacy* (7 items) (see Introduction for explanations of these sub-constructs). The measurement of these self-efficacy constructs was validated in several ways: face validity of the items was conducted by two social science faculty members with knowledge of both social cognitive theory and instrument design; and construct validity was determined through a second-order factor structure CFA (DeChenne, Enochs, and Needham 2012). Several other studies (e.g. DeChenne et al., 2015; Wheeler, Maeng, Chiu, & Bell, 2017) have also reliably used this survey to measure teaching self-efficacy in the graduate student population.

Coping was measured using Roach’s instrument (K. D. Roach 2003) that measures the frequency of six types of coping strategies in response to teaching anxiety: (1) *preparing materials* , (2) *muscular desensitization* e.g. breathing deeply or

muscular exercises, (3) *cognitive restructuring* e.g. positive thinking, (4) *preparing delivery*, (5) *visualization* e.g. imagining successfully teaching the class, and (6) *mentoring*, e.g. reaching out to other GTAs or faculty. This instrument was developed for GTAs across multiple disciplines and countries of origin to measure how GTAs reduce anxiety in preparation for teaching their class. Instrument items were based on techniques for coping with communication apprehension found in communication apprehension literature (K. D. Roach 2003). The instrument has 24 items with at least two items per construct. Participants rate the frequency of their coping activities on a 1-5 Likert scale, ranging from 1 “Never” to 5 “Always” before teaching. For example, an item from type 3 coping asks participants to rate how often they “practice saying and thinking positive self-thoughts about yourself.”

Contextual variables. Lastly, there were 32 investigator-created questions, which captured demographic and other contextual variables. Four items were to measure general anxiety (GA) among GTAs and asked participants to rate their anxiety: “*About being a graduate student/the graduate student experience,*” “*Being a TA in your most recent teaching assignment,*” “*Being a GTA generally,*” and “*In your daily life generally*.” They responded using a 1-5 Likert scale, with 1 being not anxious and 5 being very anxious. Another three items asked participants about their perceptions of teaching support from their advisor, department, and institution on a scale of 1-5, 1 being no support and 5 being very supportive of teaching. We asked participants to report the average number of hours they took to prepare for teaching each week, the number of semesters of GTA experience (>1 year of GTA experience was considered “Experienced”), and career aspirations (see **Appendix** for survey). Demographic

variables such as gender, ethnicity, department, student citizenship status or nationality, and degree sought were also included. The average length of completion for the survey was 15 minutes.

Data analysis

We calculated measures of reliability and validity to determine whether the anxiety, self-efficacy, and coping instruments accurately measured the identified variables for the GTA population. Reliability measures consistency when a testing procedure is repeated (Knekta, Runyon, and Eddy 2019), while validity is a measure of its accuracy in drawing correct inferences from survey scores (Reeves and Marbach-Ad 2016). Two forms of evidence were used to assure reliability and validity of the three surveys. First, each instrument was vetted for this project based on reported reliability scores from the literature. The teaching anxiety scale had a reported alpha coefficient 0.93, the self-efficacy measures an alpha score of 0.90, and the coping constructs of 0.94 (DeChenne, Enochs, and Needham 2012; Parsons 1973; K. D. Roach 2003). We also calculated Cronbach's alpha scores for our GTA population. Constructs with Cronbach's alpha scores greater than 0.7 indicate good reliability (Taber 2018). Second, content validity of the questions were checked based on professional judgment by experts (one psychology faculty and 3 biology faculty) as to the appropriateness of the instrument for the Biology GTA population (Reeves and Marbach-Ad 2016). Though confirmatory factor analysis (CFA) is commonly used to validate the use of an instrument with a new population, it requires a much larger data set than we had

available for this project, so we were not able to conduct this analysis (Hu and Bentler 1999; Knekta, Runyon, and Eddy 2019).

To prepare the teaching anxiety, teaching self-efficacy, and coping item results for analysis, we followed the suggested protocol for each instrument. We summed each individual's responses to the 29-items to result in a teaching anxiety score, with half of the items being reverse scored to adjust for positive phrasing (Parsons 1973). An individual could score between 29 (low anxiety) to 145 (high anxiety) on this anxiety scale. The scores for the two self-efficacy constructs were compiled separately and averaged, such that each participant had two teaching self-efficacy scores (learning environment self-efficacy and instructional self-efficacy). Final scores of each self-efficacy construct ranged from 1 (low self-efficacy) to 5 (high self-efficacy) (DeChenne, Enochs, and Needham 2012). Lastly, for coping, final summed scores for each type of coping ranged from as low as 2 to as high as 45, depending on the type (K. D. Roach 2003).

Contextual variables were processed independently from one another depending on the items. Some demographic variables were dummy coded, such as gender (1 = male, 2 = female), ethnicity (0 = non-white, 1 = white), student citizenship status (domestic = 1, international = 2), degree program (1 = MS, 2 = PhD), department (1 = BCMB, 2 = EEB, 3 = GST, 4 = Micro, 5 = Other), and teaching experience (0 = Novice GTA with < 1 year of experience, 1 = Experienced GTA with 1 year or more of experience). The term 'international student' is defined as individuals enrolled in higher education institutions who are on temporary student visas and are often non-native English speakers. The terms, 'domestic,' 'local,' or 'resident students' refers to students

who are native English speakers residing in their own country (Andrade 2006). The investigator-created items for general anxiety and perceptions of teaching support were all kept as independent items and not summed or averaged, as they were not from a validated instrument.

To address the first research question (examining the differences in teaching anxiety, teaching self-efficacy and coping among GTAs), simple descriptive statistics were calculated for each of the instruments and/or items for the entire GTA sample. Differences in the three constructs among some demographic sub-populations were explored as well.

To answer the second research question (examining how self-efficacy, coping, and contextual variables relate to teaching anxiety) we conducted multiple linear regressions (MLRs) and structural equation models (SEMs). To start this process, we first conducted correlational analyses. These correlations allowed us to initially examine the statistical significance, strength, and direction (positive or negative) of the associations between teaching anxiety and other constructs (self-efficacy, coping) and the contextual variables. Building on these correlational analyses, we developed multiple linear regressions (MLRs) that included self-efficacy and coping as well as the contextual variables as predictors within the same model. A step-wise selection procedure was used to select the most important variables that explained significant variance (R^2adj) in teaching anxiety, while maintaining parsimony. Variables were selected based on the total amount of variance explained in the model (R^2adj), the significance of each variable, and the literature. According to Tabachnick and Fidell (2007), the primary goal of regression analysis is often to investigate the relationship

between a dependent variable and several independent variables. Here, we sought to identify the combined variance in teaching anxiety that was accounted for when considering multiple independent variables (e.g. teaching self-efficacy, coping, demographic/contextual variables). All values from the instruments were z-scored for comparison.

The variables that were included in the initial model before step-wise selection were the results from the 3 instruments (teaching anxiety, teaching self-efficacy, and coping), general anxiety, demographics (gender, ethnicity, citizenship status), and contextual variables (degree sought, year in the graduate program, biology department, departmental teaching support, hours to prepare for teaching). Therefore, the full model was:

Teaching anxiety ~ Learning self-efficacy + Instructional self-efficacy + Coping 1 + Coping 2 + Coping 3 + Coping 4 + Coping 5 + Coping 6 + Total semesters of TA experience + Ethnicity + Gender + Citizenship status + Degree sought + Year in the program + Department affiliation + Average hours of teaching preparation + Perception of departmental teaching support + General anxiety about being a graduate student + General anxiety about being a TA in your most recent teaching assignment + General anxiety in being a TA generally + General anxiety in daily life

To compare multiple models and determine the most parsimonious model, a measure called Akaike Information Criterion (AIC) was calculated (Tabachnick and Fidell 2007). The AIC captures both estimated residual variance and model complexity in one statistic. If the amount of residual variance decreases, so does the AIC score. If

excessive parameters are added to the model, the AIC score increases. The score must be read in comparison to other models, and the model with the lowest AIC score is considered the model that explains the greatest variance of the dependent variable, while maintaining parsimony. Within each model, variance inflation factors (VIF) were also calculated. VIF quantifies how much the variance within a model is inflated by multicollinear variables (Tabachnick and Fidell 2007). If the VIF exceeds 4, further investigation is needed. If the VIF is greater than 10, there is multicollinearity between variables that needs to be corrected (Champernowne and Theil 1972).

Lastly, structural equation models (SEM) were also developed to supplement the results from the multiple linear regressions and evaluate the hypothesis-driven relationships between the three main constructs of teaching anxiety, self-efficacy, and coping as described in the literature. SEMs were specifically used to test the mediation of teaching self-efficacy between coping and teaching anxiety. SEMs allow for a combination of underlying latent variables and observed measures to capture causal relationships between variables of interest (Shipley 2004). Considering the constraints of our sample size, we ran 10,000 iterations of resampling of the data through bootstrapping, and analyzed the relationships between our dependent (teaching anxiety) and independent variables (teaching self-efficacy and coping) with an SEM. Model fit was assessed with a variety of fit indices, including model chi-square (χ_2), degrees of freedom, the root-mean-square error of approximation (RMSEA) and the comparative fit index (CFI). Model fit indices were compared to recommended cutoff values (Hu and Bentler 1999; Knekta et al. 2019), with RMSEA values equal or below

0.06 and CFI values at or above 0.95 indicating good data–model fit. All survey analyses were conducted in R (R Development Core Team 2018).

Results

Eighty-nine graduate students completed the Fall 2016 survey. List-wise deletion of participants was used to handle missing data when participants failed to answer more than 5 items in a row. To deal with randomly missing data, mean substitution was used. Randomly missing data was found for only 13 participants, with 12 of those participants having only a single mean substitution used. The GTA participants were predominantly white (70%), domestic (73%), experienced in teaching (70%), PhD students (90%). Participants were evenly split between genders, with 55% identifying as female (see **Table 1)**.

Reliability of instruments

For the teaching anxiety instrument, we found an alpha coefficient of 0.93; for the self-efficacy instrument, an alpha coefficient of 0.88 for each construct; and lastly for the coping instrument, alpha coefficients between 0.60-0.94 (*preparing materials* $\alpha = 0.60$, *muscular desensitization* $\alpha = 0.78$, *cognitive restructuring* $\alpha = 0.81$, *preparing delivery* $\alpha = 0.88$, *visualization* $\alpha = 0.94$, and *mentoring* $\alpha = 0.80$). Because the *preparing materials* (Coping 1) construct had poor reliability scores (< 0.70), it was removed from further analysis (Taber, 2018).

Table 1. Summary of the demographics of Graduate Teaching Assistant (GTA) participants (n = 89 total), the calculated mean teaching anxiety with standard deviation, and the average self-efficacy (SE) scores and standard deviations (SD) across each subgroup. For teaching anxiety, an individual could score between 29 and 145, from low to high anxiety. Self-efficacy is measured on a 1-5 Likert scale, with 1 being "Not confident at all" and 5 being "Very confident".

	n	% of total participants	Average teaching anxiety	SD for teaching anxiety	Average learning SE	SD for learning SE	Average instructional self-efficacy	SD for instructional self-efficacy
Gender								
Male GTAs	40	45	65.8	15.7	3.9	0.55	3.9	0.68
Female GTAs	49	55	69.7	16.5	3.9	0.69	3.9	0.77
Citizenship Status								
Domestic	65	73	69.0	15.6	3.8	0.61	3.8	0.71
International	24	27	65.1	17.6	3.9	0.66	4.1	0.79
Ethnicity								
White	63	70	68.9	14.4	3.8	0.57	3.8	0.70
Non-white	26	30	65.5	19.7	3.9	0.76	4.1	0.80
Experience level								
Novice	27	30	71.0	15.7	3.8	0.73	3.6*	0.87
Experienced	62	70	66.6	16.5	3.9	0.58	4.0*	0.64
Degree								
MS	9	10	70.0	19.0	4.0	0.47	4.0	0.74
PhD	80	90	67.7	15.9	3.8	0.65	3.9	0.74

Table 1 Continued

Department								
BCMB	25	28	69.2	16.1	3.8	0.59	3.9	0.87
EEB	31	35	66.3	17.0	3.8	0.66	3.8	0.73
GST	9	10	58	15.1	4.2	0.55	4.3	0.64
Micro	23	26	72.6	14.4	3.8	0.60	3.9	0.62
Other	1	1	61	N/A	4.7	N/A	4.3	N/A

Teaching anxiety, self-efficacy, and coping descriptive statistics

Based on Parsons' (1973) *teaching anxiety* scale, an individual could score between 29 and 145. Average teaching anxiety among the Biology GTAs was 67.4 (± 16.4 SD), indicating a mid-range level of anxiety. The minimum anxiety score for the sample was 32, and maximum was 116 (**Figure 2**). Average *self-efficacy* scores for both learning environment and instructional self-efficacy were 3.9 (± 0.64 SD), indicating higher than average perception of self-efficacy in teaching. Average coping frequency ranged from 3.62 to 23.24 depending on the coping strategy (see **Table 2** for GTA coping averages compared to their potential ranges). The Supporting Information (see **Appendix**) shows that there were no differences in teaching anxiety between GTA subgroups (e.g. gender, ethnicity, etc.), experienced GTAs had higher instructional self-efficacy, and non-white GTAs had higher frequencies of four coping strategies.

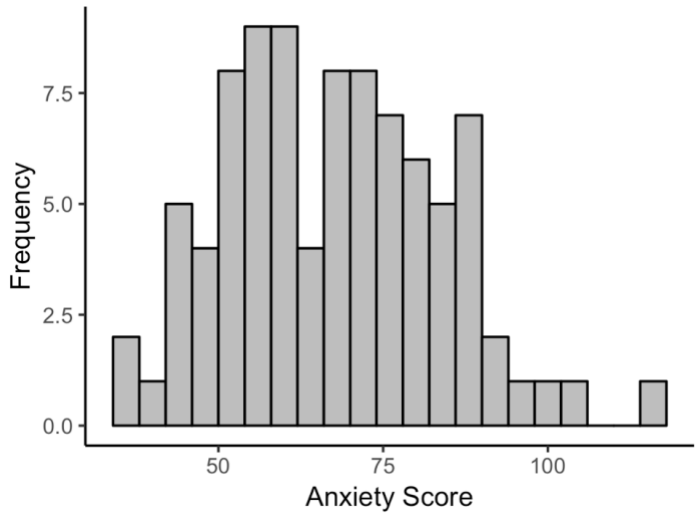


Figure 2. Distribution of teaching anxiety of GTA participants (n = 89). There is a relatively normal distribution of teaching anxiety in the GTA sample. There were 29 items in the anxiety measure, each rated on a 1-5 Likert scale. An individual could range between 29 to 145 on this anxiety scale, with 29 being the lowest level of anxiety and 145 being the highest.

Table 2. Descriptive statistics (mean and standard deviation) and potential score range of coping strategies within Biology GTAs participants (n=89). The five types of coping strategies for teaching anxiety kept in the analysis were: (1) *muscular desensitization*, (2) *cognitive restructuring*, (3) *preparing delivery*, (4) *visualization*, and (5) *mentoring*. Coping through *preparing materials* (Coping 1) was removed after Cronbach's alpha scores revealed low reliability (< 0.7).

Coping strategy	Average	SD	Range
Muscular desensitization	3.62	1.67	2-10
Cognitive restructuring	11.99	1.93	5-25
Preparing delivery	23.24	8.21	9-45
Visualization	9.93	5.07	4-20
Mentoring	5.11	1.91	2-10

Correlations of teaching anxiety, teaching self-efficacy, coping, and contextual variables

We next examined correlational relationships among variables as depicted in a correlogram (**Figure 3a and b**, R package "corrplot" (Wei and Simko 2016)). We found that both constructs of teaching self-efficacy were significantly and negatively associated with teaching anxiety (**Figure 3a**, $r = -0.59, p<0.05$). Coping strategies had significant strong to moderate positive correlations among other coping strategies (**Figure 3a**, $r = 0.30\text{-}0.60, p<0.05$) and moderate to weak positive correlations with self-efficacy constructs (**Figure 3a**, $r = 0.04\text{-}0.40, p<0.05$).

In correlations between teaching anxiety and continuous background variables (total semesters of teaching experience, hours of teaching preparation, and general anxiety items), we found that general anxiety had a significant positive relationship with teaching anxiety (**Figure 3b,** $r = 0.46\text{-}0.67, p<0.05$). Total semesters of teaching experience were also weakly negatively correlated to teaching anxiety (**Figure 3b,** $r = -0.24, p<0.05$), general anxiety in a GTA's last teaching assignment (**Figure 3b,** $r = -0.29, p<0.05$), and general anxiety in graduate school (**Figure 3b,** $r = -0.22, p<0.05$).

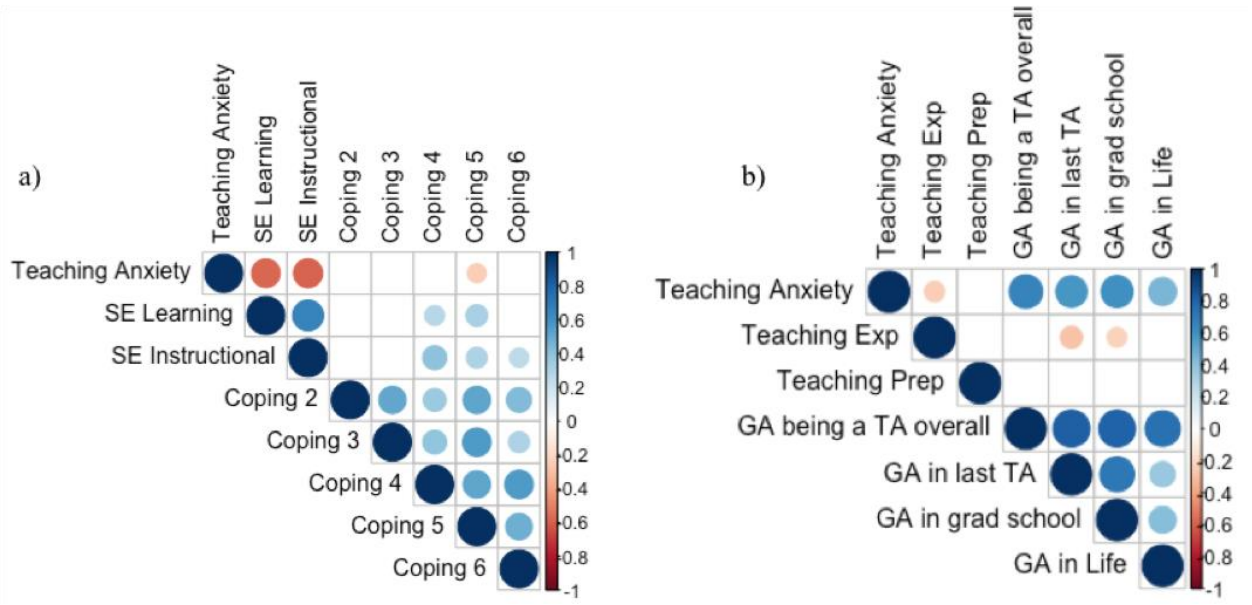


Figure 3. Correlograms of bivariate correlations among a) study constructs: teaching anxiety, teaching self-efficacy, and coping strategies (N=89). Coping 1 to 6 strategies are as follows: *preparing materials*, *muscular desensitization*, *cognitive restructuring*, *preparing delivery*, *visualization*, and *mentoring*. Coping 1 was taken out because of poor reliability scores. The second correlogram depicts correlations between b) teaching anxiety and contextual variables (total semesters of teaching experience, total hours of teaching preparation, and four general anxiety (GA) items related to general anxiety about being a graduate student, being a TA in a GTAs most recent teaching assignment, being a GTA generally, and general anxiety in their daily life). Positive correlations are displayed in blue and negative correlations in red color. Correlation coefficients are proportional to the color intensity and the size of the circle. The legend color shows the correlation coefficients according to the corresponding colors. Correlations with p-value > 0.05 are considered as insignificant and have a blank and no circle.

Model for teaching anxiety

Using multiple linear regressions, we predicted 67% of the variation in GTA teaching anxiety with learning self-efficacy, instructional self-efficacy, two items measuring general anxiety (general anxiety as a GTA, and anxiety related to their last teaching assignment), ethnicity, and citizenship status (**Table 3a**, R_{2adi}= 0.67, p <0.001, AIC=162). Coefficients of the model suggest that GTAs with higher teaching self-

efficacy and lower general anxiety will have lower teaching anxiety. Coefficients of ethnicity and citizenship status revealed that compared to non-white GTAs, white GTAs are more likely to have less teaching anxiety; and compared to domestic students, international students are more likely to have less teaching anxiety. These variables were selected from the full model via step-wise selection which also contained the demographic and contextual variables.

A second model was developed removing general anxiety items, as they were measured using four non-validated investigator-created questions (**Table 3b**, R_{2adi}= 0.46, p <0.001, AIC=208). This second model did not capture as much variance as the first. For the second model, the step-wise selection procedure chose 9 variables, 7 of which were significant in explaining the variance in teaching anxiety. These variables included both teaching self-efficacy constructs, teaching experience, and 4 types of coping measures (coping through preparing delivery, cognitive restructuring, and mentoring). The non-significant variables included hours of teaching preparation and feelings of departmental support. This model explained 46% of variance in teaching anxiety. Both models of teaching anxiety had no significant multicollinearity within the model. Variables which did not contribute (R_{2adj}) to either model and were not significant included two types of coping (muscular desensitization and visualization), gender, degree sought, year in program, department affiliation, and two of the general anxiety items. Comparing models using the AIC scores, we found that the initial model with general anxiety included was more parsimonious. VIF calculations revealed no inflation issues due to multicollinearity.

Table 3. Multiple linear regressions were built to a) determine what variables contributed to GTA teaching anxiety in Fall 2016 including general anxiety items and b) without general anxiety items. Both models were significant, explaining over 46% of the variance in teaching anxiety (n=89). The first model is the most parsimonious, with 67% of the variance in teaching anxiety explained. Instruments were z-scored for teaching anxiety, self-efficacy, and coping scores, to facilitate standardized comparisons across instruments.

Model	Predictor Variables	Standardized Coefficients	R^2_{adj}	p-value	AIC	VIF
a) Teaching Anxiety	Learning self-efficacy	-0.31***	0.67	< 0.001	162.36	1.91
	Instructional self-efficacy	-0.27***				1.95
	Anxiety as a TA in most recent teaching assignment	0.21*				2.31
	Anxiety as a TA generally	0.30***				2.26
	Ethnicity (non-white = 0; white = 1)	-0.42*				2.21
	Citizenship status (domestic = 1; international = 2)	-0.47*				2.20
b) Teaching Anxiety	Learning self-efficacy	-0.24*	0.46	< 0.001	208.46	2.12
	Instructional self-efficacy	-0.36**				2.03
	Total semesters teaching	-0.04*				1.12

Table 3 Continued

Coping through cognitive restructuring	0.18 *ns*	1.49
Coping through preparing delivery	-0.24*	2.08
Coping through mentoring	0.24*	1.60
Hours preparing to teach	-0.02, *ns*	1.22
Departmental support	-0.13, *ns*	1.09

**** = p<0.001; ** = p<0.01; * = p<0.05*

To further probe the relationships between teaching anxiety, teaching self-efficacy and coping, we also explored the use of an SEM model. However, even with the use of bootstrapping, we did not have a large enough sample size to produce an acceptable model. We provide this model in the Supporting Information (see **Appendix**), showing model fit statistics and construct relationships, as a starting point for others to more fully explore these relationships.

Discussion

In answering our research questions, we found that teaching anxiety had a normal distribution in our population, with the majority of GTAs reporting moderate levels of anxiety. This anxiety was universal among subgroups of GTAs. GTAs had slightly higher than average teaching self-efficacy and a range of coping frequencies. From our models, teaching self-efficacy negatively predicted teaching anxiety in Biology

GTAs in our sample. GTA general anxiety was positively related to teaching anxiety, although those results should be treated with caution because of the unvalidated nature of the general anxiety items. Our statistical models also revealed that white and international students were more likely to have lower teaching anxiety compared to non-white and domestic students, respectively. Correlations indicated that higher coping frequency was related to higher teaching self-efficacy, suggesting a potential indirect role of coping on teaching anxiety, however, the SEM model was unable to verify these relationships. Higher self-efficacy seems to be the most direct way to lower teaching anxiety, but coping should be further explored as a potential factor as well.

Building greater teaching self-efficacy may reduce teaching anxiety

Both self-efficacy constructs significantly contributed to teaching anxiety, with self-efficacy negatively correlated to teaching anxiety. As indicated in the introduction, self-efficacy may be built by four main mechanisms: mastery experiences, vicarious experiences, social persuasion, and emotional or physiological arousal. Bandura (1978) purported that mastery experience was the strongest and most influential in building self-efficacy in a task. Instructors who have greater authentic classroom teaching experiences (e.g. guest lecture, instructor of record, not just a grader) should have higher teaching self-efficacy (Morris and Usher 2011). Indeed, GTAs with more teaching experience in our study had higher instructional self-efficacy. We also found that both learning environment self-efficacy and instructional self-efficacy were important in the model predicting teaching anxiety. Although these relationships are bi-directional and

self-reported (GTAs who self-report low teaching anxiety may self-report high teaching self-efficacy even if they are not effective teachers), programs that work to increase teaching self-efficacy of Biology GTAs should see a concomitant decrease in teaching anxiety, which is linked with better instructional quality (YoonJung Cho et al. 2011; Coates and Thoresen 1976).

Coping frequency may be related to teaching self-efficacy

Our results did not indicate coping as a direct predictor of teaching anxiety, but correlations demonstrated the possibility that coping may be related to self-efficacy. Thus, there is the possibility that coping affects teaching anxiety indirectly through self-efficacy. One potential mechanism is that GTAs who perceive high levels of self-efficacy towards a teaching task may also be building coping efficacy to manage anxiety. Bandura (1988) indicates that in order to understand how an individual appraises external threats (anxiety) and their responses (coping), it is necessary to understand how an individual judges their coping capabilities (coping self-efficacy). Further investigation is needed, however, with a much larger sample size in order to explore the proposed indirect relationship between coping, self-efficacy, and anxiety.

The significant coping strategies which emerged from the second regression model (preparing classroom delivery and seeking the advice of mentors) are both aligned with two families of coping: *problem-solving* and *information-seeking* (Henry et al. 2019; Skinner et al. 2003). Both these strategies require planning or preparing as a response to external stressors. Problem-solving attempts to resolve the stressor, through planning and/or enacting a potential solution, while information-seeking

attempts to learn more about the stressor via talking to other people, research, etc. These coping strategies fall under *adaptive* coping (Henry et al. 2019; Skinner et al. 2003), which theoretically lead to positive increases of self-efficacy and reductions in anxiety. Though we can categorize the use of such coping strategies as adaptive based on their descriptions, coping is dynamic depending on the context in which it is used. How coping is enacted and manifested in an individual can change its effectiveness in managing anxiety.

Interestingly, when Roach (2003) examined correlations between teaching anxiety and the self-reported frequency of coping strategies, he found positive correlations. Individuals with higher anxiety may actually be seeking out more mentoring coping, hence the positive coefficient in the regression model (K. D. Roach 2003). Alternatively, the positive coefficient may also be interpreted as a coping strategy which is being used more frequently but not effectively, and thus the teaching anxiety remains high, leading to a positive relationship. So, the coping is not necessarily maladaptive, but ineffective. It may also be the case that the use of frequent and effective coping may decrease anxiety, leading to a negative relationship between the two. In our second multiple linear regression modelling teaching anxiety, we also found both positive and negative relationships between anxiety and coping. This indicates that qualitative research is needed in combination with these quantitative measures to accurately interpret these correlative relationships. Without this information, it is difficult to make inferences about the exact nature of coping with other constructs in this study.

White and international GTAs were more likely to have less teaching anxiety

Our models also revealed that ethnicity and citizenship significantly contributed to explaining variations in Biology GTA teaching anxiety. White students were more likely to have less teaching anxiety than non-white GTAs. A majority of these white GTAs in our study were experienced GTAs with 71% having more than 1 year of teaching experience. Thus, this group may have developed higher teaching self-efficacy and less teaching anxiety. Ethnic minority GTAs may also be facing greater barriers to building self-efficacy or effective coping strategies, instead facing other unique stressors (El-Ghoroury et al. 2012) and thus have higher teaching anxiety, compared to white GTAs. The literature suggests that those not acclimated to Western cultures and languages may have more teaching anxiety (Bhochhibhoya, Dong, and Branscum 2017; George, Saclarides, and Lubienski 2018; Mallinckrodt and Leong 1992; K. D. Roach and Olaniran 2001), however, our data suggested the opposite, with international students being more likely than domestic students to have less teaching anxiety. When Roach and Olaniran (2001) studied 201 international graduate students across multiple disciplines, they also found that international GTAs had low levels of intercultural communication apprehension or anxiety, expressing a great willingness to communicate with people from a different culture (K. D. Roach and Olaniran 2001). This difference in teaching anxiety between student citizenship status groups may potentially be attributed to more effective coping strategies as we also found that non-white, international GTAs had higher frequencies of four coping strategies compared to white, domestic GTAs (see **Appendix**).

Surprisingly, teaching anxiety levels were mostly similar between male and female GTAs

Despite evidence suggesting female graduate students suffer higher rates of general anxiety and depression than male graduate students (T. M. Evans et al. 2018), we did not find gender differences in teaching anxiety. Teaching is a role often dominated by women, especially in primary and secondary education (Geiger 2018). Women gravitate toward teaching-centered occupations more often than men, with sometimes greater self-efficacy for the task compared to their male counterparts (Betz and Hackett 1997; Zeldin, Britner, and Pajares 2008). When comparing how gender role socialization might contribute to gender differences in self-efficacy and confidence, Betz and Hackett (1997) found that women demonstrated significantly greater self-efficacy for traditionally female occupations and much lower efficacy for traditionally male occupations compared to men. These trends in self-efficacy between genders, however, have not always been consistently observed (Bailey and Bailey 2006; Connolly, Lee, and Savoy 2018; Schoen and Winocur 1988). More recently, when comparing effects of TPD between genders, Connolly, Lee, and Savoy (2018) found female graduate students had lower self-efficacy than male GTAs when both groups lacked any TPD experience. Interestingly, this gap became significantly smaller as women became more engaged in TPD activities.

In our study population, GTAs are supported by many TPD opportunities at the institutional and departmental level, possibly increasing self-efficacy and decreasing teaching anxiety in our female GTA population (Reeves et al. 2018). Though we did not explicitly ask about the intensity of their TPD participation, 70% of the study participants

were *experienced* GTAs, making the likelihood of GTAs having participated in TPD (via CIRTL programs, early-semester orientation or course preparation meeting, and workshops let by institutional Teaching and Learning programs) higher.

Implications for GTA attrition, professional identity, and teaching quality

Teaching anxiety is one facet contributing to overall graduate student well-being. Generally, feelings of anxiety can escalate into diagnosed anxiety disorder, which impedes functioning in daily life. The anxieties graduate students face affect not only their overall mental health, but also reduce their retention in graduate programs and academia (Bair and Haworth 2004; Kinman 2001; Sheltzer and Smith 2014; UC Berkeley Graduate Assembly 2014). Therefore, the level of anxiety experienced by individual graduate students may contribute to who persists in academic careers and how they perform in their jobs if they do persist.

Some of this anxiety may be attributed to the multiple responsibilities of graduate students. During graduate school, students are in a state of transition where they experience a variety of identities and roles (Kajfez and McNair 2014; Muzaka 2009; Winstone and Moore 2017); anxiety in response to balancing simultaneous roles and responsibilities as teachers, researchers, students, and employees can be expected. Though we have only addressed anxiety related to teaching, research anxiety or anxiety related to conflicting roles as a graduate student has yet to be studied. Some would argue that research is the primary identity graduate students must develop during graduate school; with teaching being perceived, at best, as a resume builder, and at worst, as a punishment for those unable to acquire fellowships for teaching releases

(Austin and McDaniels 2006; Austin and Wulff 2004). Recent data, however, suggest that graduate student investment of time in TPD may be beneficial for research preparation (Shortlidge and Eddy 2018). Examining how research anxiety relates to teaching anxiety, how these anxieties change over time (especially as GTAs grow in mastery experiences), and *why* GTAs are anxious needs further exploration.

Teaching professional development (TPD) opportunities can be leveraged to develop GTA teaching self-efficacy and coping skills. Previous explorations of teaching self-efficacy in STEM GTAs revealed the importance of hours and perceived quality of GTA TPD (DeChenne et al. 2015). As the growing evidence suggests (Yoonjung Cho et al. 2011; Connolly, Lee, and Savoy 2018; Pelton 2014; Reeves et al. 2018; Williams 1991), TPD opportunities allow GTAs to build self-efficacy and reduce anxiety in teaching. Reeves et al. (2018) examined the impact of GTA training programs at three separate institutions and determined that regardless of the differences in program settings, TPD was associated with gains in content knowledge and self-efficacy, and decreases in teaching anxiety. These decreases in teaching anxiety should positively impact student learning (Marso and Pigge 1998; K. D. Roach 2003) because teaching anxiety has been associated with negative grading practices (Marso and Pigge 1998), rapport and interpersonal relationships with students (Hagenauer, Hascher, and Volet 2015), and academic performance (Hadley and Dorward 2011). Equipping our future Biology faculty with the tools to discuss anxiety and ways to cope, may improve the success of future instructional faculty and undergraduate education broadly.

Limitations and assumptions

As with all studies, the results must be interpreted in light of our limitations and assumptions. The results of this study are not generalizable, as we sampled from a self-selected pool of Biology GTAs from one institution. Three main methodological limitations and one broad assumption also restrict our ability to generalize results to a wider population, including: 1) self-reporting of anxiety, 2) using investigator-created items for general anxiety, 3) measuring frequency of coping, and 4) the assumption that anxiety is a negative emotion.

Critics of measuring teaching anxiety through self-reporting assert that there is poor evidence to suggest there is any influence in teaching performance (Coates & Thoresen, 1976) or it conflates teaching anxiety with merely "teaching concerns" (Keaveny & Sinclair, 1978). However, teaching anxiety may be perceived to some extent by an external observer (Marso and Pigge 1998; Parsons 1973; Williams 1991). To test this, Parsons (1973) had 25 preservice teachers score their own teaching anxiety and then correlated those scores to ratings provided from teacher supervisors' after a teaching observation. They found evidence suggesting that the teaching anxiety reported on the scale corresponded to what may be externally perceived teaching anxiety (r = 0.24-0.54).

The second limitation pertains to the items in which we measured general anxiety among GTAs. As we mentioned in the Methods, because our sample size did not allow for any of our measures to undergo confirmatory factor analysis (Knekta et al., 2019), we were unable to even initially test whether the general anxiety measures we used formed a true "general anxiety" factor. Thus, although they were useful in exploring

potential relationships between different types of anxiety, these results should be treated with caution.

The third limitation involves measuring coping. Bandura (1988) indicated coping efficacy was an integral component in exercising control over anxiety arousal. However, in this study, the instrument we used measured coping frequency (Roach, 2003). Though coping frequency can be used as a marker for coping strategies, it is not equivalent to measuring efficacy of coping. Roach (2003) agrees that it is possible that TAs with high teaching anxiety could spend hours preparing for a class and still be unsuccessful because of *how* they prepared or the efficacy of coping. Roach (2003) suggests that this is where the GTA supervisor or teaching mentor must help the GTA make more efficacious coping decisions. Future work could attempt to capture the effectiveness of coping strategies enacted instead of only frequencies.

Lastly, investigating anxiety under this framework, we recognize the implicit assumption that anxiety is a negative emotion. However, Yerkes and Dodson (1908) established a threshold in which “arousal” or anxiety can actually increase productivity, and Pekrun et al. (2007) acknowledged anxiety’s ability to be an activating emotion in terms of motivation. Pelton (2014) suggested that reducing *all* sources of anxiety is not ideal. Thus, too much or too little anxiety about teaching are both likely impediments to teaching effectiveness, and to a certain extent, some level of doubt or lack of confidence may provide the impetus to improve teaching effectiveness (Wheatley 2005). Anxiety can only be motivating and productive, however, if it is paired with constructive and effective coping strategies. If the coping is maladaptive and destructive, anxiety may then have a negative impact.

Conclusions

To tackle the anxiety epidemic in academia, particularly in regard to graduate student teaching, there must be opportunities for students to gain teaching self-efficacy. TPD activities or training opportunities for GTAs pose a tangible, effective method for institutions and departments to effectively increase instructional quality. TPD workshops may also provide efficacious coping strategies to regulate other external stressors which cause anxiety. Projects focused on TPD of graduate students, such as the Biology Teaching Assistant Program (BioTAP) or the Longitudinal Study of Future STEM Scholars (LSFSS), can further the scholarship necessary to understand the relationships among graduate students, teaching, anxiety, and coping.

CHAPTER II

FINDING A BALANCE: CHARACTERIZING TEACHING AND RESEARCH ANXIETIES IN BIOLOGY GRADUATE TEACHING ASSISTANTS (GTAS)

A version of this chapter has been submitted for publication to *CBE-Life Sciences Education* by Miranda Chen Musgrove, Kate Petrie, and Elisabeth E. Schussler.

The first author contributed to the research concept, data collection, data analysis, and manuscript writing. The second author contributed to the data analysis and manuscript writing. The third author contributed to the research concept and manuscript writing.

Abstract

Graduate students in the United States are experiencing increased levels of anxiety, affecting their overall mental health and attrition in graduate programs. Yet we are only beginning to understand what contributes to graduate student anxiety. Biology Graduate Teaching Assistants (GTAs) occupy an “ambiguous niche” in academia with simultaneous roles as teachers, researchers, students, and employees. Tensions between these roles can contribute to anxieties related to teaching and research responsibilities. To explore GTA teaching and research anxieties, we interviewed 23 Biology GTAs at a research-intensive southeastern university. Our exploratory qualitative study was guided by Social Cognitive Career Theory (SCCT). SCCT describes the cognitive, behavioral, and contextual variables which influence the formation and persistence of a person’s career interests and trajectory. In light of this framework, we predicted that anxiety may be an additional variable impacting career development and interests. Using a card sort method, participants listed and explained their anxieties related to teaching and research roles. Thematic analysis of interview transcripts revealed five major factors related to GTA anxieties: **impact on self**, **impact on others**, **lack of self-efficacy**, **role tension, and personal anxieties.** These factors were present for both teaching and research roles, but in different proportions. Lack of self-efficacy was most prevalent for research anxieties, compared to teaching anxieties, where impact on others (e.g. students) was more prevalent for teaching anxieties. Conflicts between teaching and research roles also led to anxiety, particularly with regard to time constraints. GTAs with academic career aspirations appeared to express less anxiety about role tensions or time constraints compared to GTAs with non-

academic career goals. By investigating GTA anxieties, this work can inform professional development or mental health interventions for GTAs and encourage greater awareness and dialogue about GTA mental health issues in academia.

Introduction

Graduate students in the United States are experiencing increased levels of anxiety, affecting their overall mental health and attrition in graduate programs (T. M. Evans et al. 2018; Hish et al. 2019; Levecque et al. 2017; Nagy et al. 2019). A recent study found that one in three graduate students was depressed, a rate six times higher than the general public (T. M. Evans et al. 2018). Nagy et al. (2019) found high rates of mental health problems in biomedical doctoral students, with participants experiencing burnout, depression, and anxiety. Despite these reports of mental health issues in graduate students, we are only beginning to understand the contributing factors to graduate student mental health.

Our current understanding of the causes of graduate student mental health issues, such as anxiety, are wide ranging—lack of advisor support, lack of social support, poor perception of employment prospects, or family/monetary concerns, to name a few (Devos et al. 2017; Golde 2005; Hish et al. 2019; Levecque et al. 2017; Mousavi et al. 2018). For example, when Levecque et al. (2017) surveyed over 3,000 doctoral students in Belgium, they found that work-family conflict can exacerbate a graduate student's anxiety (Levecque et al. 2017). If these conditions persist for a graduate student, they can lead to attrition out of the program (Devos et al. 2017; Golde 2005). Despite the growing number of studies that attempt to pinpoint the causes of graduate student mental health issues, we often fail to consider how balancing multiple

roles over their degree program may exacerbate anxieties (Lane, Hardison, et al. 2019). For example, STEM Graduate Teaching Assistants (GTAs) often teach undergraduate labs or discussions along with taking their own classes and conducting research (Gardner and Jones 2011; Prieto and Scheel 2008; Sundberg, Armstrong, and Wischusen 2005). Thus, in academia, role tension, such as between teaching and research, may result in its own set of anxieties.

This study focuses specifically on anxiety (versus stress), which is defined as the state of anticipatory apprehension over possible deleterious happenings (Bandura 1988). Anxiety's physiological responses are similar to those of stress: increased levels of cortisol, faster heartrate, dilated pupils, etc. However, with anxiety, these physical changes accompany general feelings of concern, tension, or worry about an anticipated event or outcome that may or may not actualize in the future; whereas stress may refer to the cognitive, emotional and biological reactions to specific and current life events (American Psychological Association 2020; Pekrun et al. 2007). Despite its anticipatory nature, intense anxiety can be debilitating to an individual as well as those around them. By examining one symptom of mental health in our graduate students at great depth, this study aims to better support graduate student well-being.

Graduate students may struggle with anxiety related to teaching, research, and balancing these roles

For graduate students who want to pursue a faculty position, their professional identity will require balancing multiple roles, e.g. researcher, teacher, advisor, administrator, etc. (Adler and Adler 2005; Kajfez and Matusovich 2017a; Kajfez and

McNair 2014; Sverdlik and Hall 2019; Winstone and Moore 2017). During graduate school, students may test their affinity for these different roles, and practice balancing the demands of each (Goetz et al. 2013a; Kajfez and McNair 2014; Winstone and Moore 2017). Graduate students also observe their advisors and departmental culture to identify which roles are most valued (Austin and McDaniels 2006) e.g. research, then teaching, then service at some institutions. Even when not pursuing an academic position, many graduate students are required to teach as part of their assistantship, forcing them to balance roles they may or may not even want. Some graduate students are told directly not to spend time on teaching to reserve more time for research, causing external tension in regards to these roles (Lane, Skvoretz, et al. 2019). The extent to which GTAs balance (or fail to balance) these multiple roles has only begun to be explored in the literature (Kajfez and McNair 2014; Nicklin, Meachon, and McNall 2019; Winstone and Moore 2017), and should be explored as a factor in graduate student mental health.

Research universities often rely on graduate students for instruction, especially for large enrollment classes, making the quality of their instruction important to undergraduate student success and retention. Biology GTAs, for example, teach over 91% of freshman Biology labs and discussions nationally (Sundberg, Armstrong, and Wischusen 2005). The Longitudinal Study of Future STEM Scholars (LSFSS, Connolly et al. 2016) found that nearly all (94.9%) of a 3,000 STEM PhD sample had taught undergraduates during their doctoral programs. Within 5 years after graduation, almost half of those STEM doctoral graduates went on to teach in postsecondary institutions

(Connolly et al. 2016), meaning they also continued to impact undergraduate instruction.

Graduate students often find themselves teaching with little to no pedagogical professional development (Gardner and Jones 2011; Prieto and Scheel 2008), all while establishing research projects and navigating departmental cultures. As a result, GTAs may experience a lack of confidence about their teaching (Pelton 2014; Prieto and Altmaier 1994; Reeves et al. 2018), resulting in teaching anxiety. Cho et al. (2011) identified a variety of GTA concerns that might produce anxiety, including class control, external evaluation, teaching tasks, student impact, holding dual roles, and time management. Research in K-12 and university contexts has found that teaching anxiety negative impacts teaching behavior and performance (YoonJung Cho et al. 2011; Coates and Thoresen 1976; Parsons 1973; Pelton 2014). Given university reliance on GTAs for teaching, factors that decrease instructional quality (such as teaching anxiety or role tension) may greatly influence the quality of undergraduate education at the institution.

Though teaching anxiety has been measured and tested (Parsons 1973; Pelton 2014; K. D. Roach 2003), there are few studies which explicitly investigate graduate student research anxiety, how it may impact career goals, and the possible tension between teaching and research roles. Institutions not only rely on graduate student's teaching for large enrollment course, but also rely on their successful research output. With mounting pressure to "publish or perish," graduate student productivity is critical to the successful functioning of large, research-driven universities (National Academies of Sciences Engineering and Medicine 2018). Their productivity also determines their

career prospects, particularly if graduate students aim to pursue increasingly competitive academic appointments (Larson, Ghaffarzadegan, and Xue 2014). A study on biomedical doctoral students found that less than 20% of Ph.D.'s in the biological sciences moved into tenure-track academic positions within 5-6 years after receiving their degree (Fuhrmann et al. 2011), leading many graduate students to consider "non-traditional" career paths (Clair et al. 2017; Lindholm 2004) or teaching positions. One might infer that research anxiety in this potential future faculty population would be relatively high. However, not all GTAs aspire to remain in academia as part of their future careers (Connolly, Lee, and Savoy 2018; Fuhrmann et al. 2011). The research anxiety of this population may be relatively different from those pursuing academic positions. Therefore, it seems reasonable to expect that a GTA's career aspirations may be related to their research and teaching anxieties; we explore these potential relationships using the Social Cognitive Career Theory below.

Theoretical framework: The Social Cognitive Career Theory (SCCT)

The Social Cognitive Career Theory (SCCT) provides a theoretical framework for studying the role anxiety may play in graduate students, particularly in relation to their career prospects (**Figure 4**). The SCCT was developed to identify the cognitive variables which influence a person's career interests and trajectory (Bandura 1993; Lent, Brown, and Hackett 1994). For our study, we propose a modification to the original model (see red boxes in **Figure 4**) by inserting teaching anxiety and research anxiety as proposed factors in career development. These anxieties would be strengthened or weakened as a result of an individual's *learning experiences* (e.g. teaching in a

classroom, conducting research in a lab), and would therefore influence the cognitive variables of *self-efficacy* (e.g. “Can I teach / do research well?”) and *outcome expectations* (e.g. “What will happen if I teach / conduct research poorly?”), thus impacting career-related choices and performance in the future.

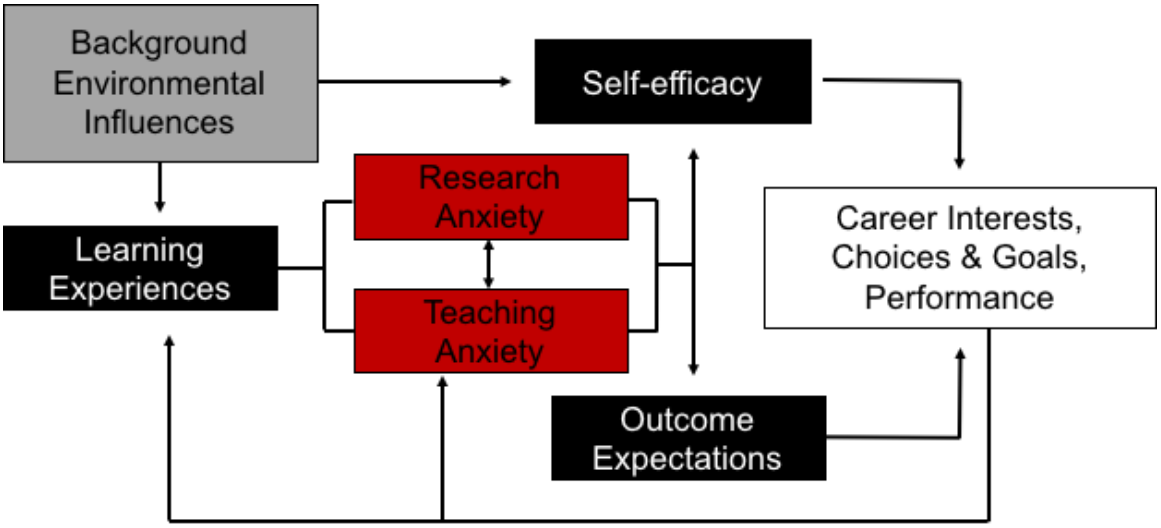


Figure 4. Modified theoretical model from the Social Cognitive Career Theory (SCCT), depicting the cognitive and contextual factors which influence career interest development. The SCCT aims to explain three interrelated aspects of career development: (1) how basic academic and career interests develop, (2) how educational and career choices are made, and (3) how academic and career success through performance is obtained. These three outcomes are displayed in the white box. The grey box indicates background or contextual components (e.g. demographics, teaching and research culture) and the black boxes are the main cognitive drivers that contribute to career development. The anxieties we are studying have been added to the model in red boxes based on their known inverse relationship with self-efficacy. Teaching / research anxiety would mediate self-efficacy expectations and outcome expectations, and these anxieties are strengthened or weakened as a result of learning experiences.

The placement of anxiety in the model is guided by existing research on the relationship between anxiety and the SCCT variable of self-efficacy. Self-efficacy is a critical component mediating anxiety and a key cognitive variable in career development and interest (Lent, Brown, and Hackett 1994, 2000). Self-efficacy is the belief or confidence in one's ability to successfully carry out a specific task or course of action (Bandura 1988; Lent, Brown, and Hackett 2000) and has been studied in the GTA population (Connolly et al. 2016; DeChenne et al. 2015; DeChenne, Enochs, and Needham 2012; Hish et al. 2019; Reeves et al. 2016). Anxiety and self-efficacy often vary together in a feedback loop, with greater self-efficacy being related to less anxiety and vice versa (Bandura 1988). These two variables have downstream effects that impact the career interests, choices, and career performance of graduate students.

Cognitive variables such as self-efficacy and anxiety are dynamic; as shown in the model, they change depending on a GTA's learning experience and background influences, meaning self-efficacy and anxiety would be expected to change over the course of a graduate degree program (e.g. the impact of professional development on GTAs, see Connolly et al., 2016). As proposed by Bandura (1988), mastery experiences are one of the dominant pathways to building self-efficacy for a task, and thus reducing anxiety towards said task (Bandura 1988). For example, in a study modelling the relationship between stress, burnout, and depression in biomedical doctoral students, Hish et al. (2019) found that mastery of a skill mediated the relationship between stress and burnout, and between stress and depression (Hish et al. 2019). As graduate students build their skills in teaching and research, there should be a theoretical increase in self-efficacy and related decline in anxiety toward those tasks.

Concomitantly, graduate students may also master balancing teaching and research roles (Austin and McDaniels 2006; Bucher and Stelling 1977), leading to reduced role tension and anxiety between them.

Using the SCCT model, these perceptions of self-efficacy and anxiety would inform a GTA's career aspirations, either by encouraging or discouraging goals aligned with given tasks. For example, perceptions of task competence or enjoyment in teaching (e.g. positive classroom experience) or research (e.g. publication) would decrease anxiety related to those roles, positively impact self-efficacy and outcome expectations and potentially support a student who desires a faculty position. While SCCT does not explicitly include the element of time in the framework, SCCT represents the *process* of career interest formation and the feedback loops in the model suggest the passage of time. As an example, a GTA may begin graduate school with no specific career interests, high self-efficacy for research and low self-efficacy for teaching, but find that over time they enjoy teaching, gain self-efficacy, and start to consider a future career in teaching. Conversely, a GTA who begins with a high self-efficacy for research and then has poor experiences with research tasks (e.g. too many rejected manuscripts), may then experience high anxiety for research, declines in self-efficacy, and develop negative outcome expectations over time, leading to a disinterest in careers with a research component.

For the purposes of this study, we will be using the SCCT framework to explore the implications of teaching and research anxieties in Biology graduate teaching assistants (GTAs), including how they change over time and whether they align with academic or non-academic career intentions of the GTA participants. Although we will

be looking for trends in the sample population, we are also aware that anxiety is not uniform among certain sub-groups of the population. For example, minorities and women typically experience greater difficulties coping with mental health issues such as anxiety which may impact their career intentions (T. M. Evans et al. 2018). This leads to the possibility that anxiety may differentially impact certain ethnicities, genders, or other minoritized populations in terms of their career interests, potentially increasing their attrition from STEM careers. Thus, looking for trends beyond the overall sample population is important to inform efforts to support more diverse future faculty; efforts to lower anxiety may remove one barrier to academic success for these groups.

Rationale and research questions

This study characterized the anxieties related to teaching and research roles, the potential for role tension among these responsibilities, and whether these anxieties are different based on a GTA's career aspiration for a group of GTAs in Biology at one institution. We also explored the factor of time because of the potential for changes in self-efficacy and anxiety impacting career intentions as the students advanced through their graduate programs. As the first study to compare teaching and research anxieties and their potential relationships, we asked three main research questions:

1. What teaching and research anxieties do Biology GTAs experience and how do these anxieties compare? How do these anxieties compare for each role?
2. Do these teaching and research anxieties change over one year?
3. Do teaching and research anxieties differ based on GTA career aspirations?

By investigating these questions, we may better understand the conflicting anxieties Biology GTAs experience and consider how to best support graduate students' well-being.

Methods

Study population

This study was approved by the University's Institutional Review Board (IRB-16-03235-XP). Biology GTAs at this large research-intensive southeastern university were our study population. The GTAs were recruited from across the University's Division of Biology through a listserv of graduate students from three departments and one program. As of Fall 2016, 211 graduate students in the Division of Biology were enrolled in a Master's or Ph.D. program, with 94% of graduate students seeking a Ph.D., and 55% identifying as female.

Data collection

In October 2016, an online survey was deployed to Biology graduate students via the Qualtrics survey software. The e-mail targeted individuals who were either currently teaching or who had been a GTA previously. This survey collected quantitative data for another study (Musgrove and Schussler, in review), but was also used to recruit participants for this study. Of the 89 Biology GTAs who completed the survey, 26% (n = 23) indicated that they would be interested in participating in follow-up interviews.

Interviews of graduate students were conducted twice over one year to collect in-depth perceptions of teaching and research anxieties. All GTA demographics were collected using the survey disseminated in Fall 2016. We collected participants' gender,

ethnicity, citizenship status (international vs. domestic), teaching experience (number of semesters as a GTA), age, degree program, year in the graduate program, and department affiliation. GTAs in the interview pool were 70% female, and 74% white (**Table 4**). All interviews were conducted by the first author (M.C.M.). Each interview was approximately 60-90 minutes long. A small monetary compensation of $10 was offered to each graduate student for each interview, which was disseminated after the interview was complete.

Table 4. Demographics of the 23 Biology GTAs interviewed over 2016-2017.

	n	**% of total participants (n = 23)**
Gender		
Male	7	30
Female	16	70
Citizenship Status		
Domestic	17	74
International	6	26
Ethnicity		
White	18	78
Non-white	5	22
Experience level*		
Novice	10	43
Experienced	13	57
Career aspirations		
Academic	11	48
Non-academic	12	52
Degree		
MS	4	17
PhD	19	83
Year in Program		
1	9	40
2	7	30
3	7	30

Table 4 Continued

Department**		
BCMB	2	9
EEB	12	52
GST	3	13
Micro	5	22
Other	1	4

***** *Experienced GTAs = >1 year of GTA experience; Novice GTAs = <1 year of GTA experience*
****** *BCMB = Biochemistry & Cellular and Molecular Biology; EEB = Ecology & Evolutionary Biology, GST = Genome Science & Technology, Micro = Microbiology*

Biology GTA Interviews

Interviews were conducted with 23 Biology GTAs in Fall 2016, and again with the same sample of participants in Fall 2017 using the same interview protocol, with the addition of a few retrospective questions in 2017. Interviews were audio-recorded and probed four main topics: (1) a GTA's perception of their experience level, knowledge of teaching, and effectiveness in teaching; (2) their teaching and research anxieties; (3) coping strategies enacted; and (4) their professional identity/career aspirations as teachers and researchers. To probe the second and third topics, card sorts were used as a tool to guide conversations about teaching and research anxiety and coping. Card sort activities make abstract concepts more tangible for participants, especially as interactive, object-based aids to qualitative interviews (Conrad and Tucker 2019). For these interviews, one set of cards contained hypothesized factors related to teaching anxieties (e.g. student behavior, grading, etc.) and the other set contained hypothesized factors related to research anxieties (e.g. writing grants, data analysis, etc.). Blank cards were also available for participants to write their own factors not captured by the existing cards. The interview protocol and card sort items were vetted by 2 faculty

members (both trained Biologists and Education Researchers), one Biology education post-doctoral researcher, and two Biology graduate students to ensure we broadly captured possible anxiety experiences of Biology GTAs.

Before reading any of the cards, we first asked participants to list any teaching and research anxieties. None of the participants indicated a total absence of anxiety for either topic. Participants were then asked to read the cards from one set, pick as many relevant anxiety cards for teaching and research, respectively. They then explained what about the factor on the card made them anxious, the perceived impact of this anxiety on their teaching or research, and how/if they coped with that factor. Participants would often add anxieties not captured in the cards. Interviews were audio-recorded and transcribed in order to conduct open coding to identify themes (Boyatzis 1998). Our full interview protocol and cards are available in the **Appendix.**

Data analysis

To identify themes and categories regarding teaching and research anxiety of the participants, thematic analysis of interview transcripts was conducted first using the Fall 2016 interview data. Open coding for emergent themes (also called “initial coding”) was conducted on all interview data to capture the experience and perceptions about teaching and research anxiety of GTAs (Charmaz 2006; Saldaña 2012; Strauss and Corbin 2008). The process was inductive, wherein the researchers identified major codes, categories, and themes without any predetermined codebook (Saldaña 2012).

The initial codebook was created by the first author after reading the Fall 2016 interviews. A method of constant comparison was then followed by the first author and

two undergraduate research assistants (RAs, including co-author K.P.) to analyze interview transcripts and refine the codebook. Coders began by independently coding the same set of six randomly selected interview transcripts from 2016, then came together to determine the percentage of code agreement. Coding units were participant responses to each anxiety card chosen for teaching or research. If there was disagreement lower than 80%, coders would re-examine the codebook, refine definitions of codes and their broader themes, and re-code a new set of transcripts. As new codes emerged, or new understandings developed, the codebook was revised and previous interview transcripts were re-analyzed to look for the new codes (Glaser and Strauss 1967; Schwandt 2007). From these descriptions and codes, major themes were then identified in the codebook. A major theme provided explanation for distinct aspects of the overarching finding. The codebook themes and descriptions were reviewed by 2 faculty members (both trained Biologists and Education Researchers), one Biology education post-doctoral researcher, and two Biology graduate students to ensure codebook clarity.

Three iterations of this method were conducted among coders to reach a minimum agreement of 80% consensus of themes found (Landis and Koch, 1977). Inter-rater reliability of the themes was calculated between the coders. Inter-rater reliability is a measure of agreement among raters; it represents the extent to which the data collected in the study are correct representations of the variables measured (LeBreton and Senter 2008; McHugh 2012). Greater consensus among raters indicates higher reliability of the codes. After the last reliability iteration, among 3 coders, 98% agreement was calculated across 3 different interview transcripts from Fall 2016.

The codebook which emerged from the analysis of Fall 2016 interviews was used to code subsequent interviews conducted on the same group of GTAs in Fall 2017. The first author finished coding the remaining Fall 2016 interviews, and the two RAs coded interviews from Fall 2017. All coding was recorded and conducted in Microsoft Excel, with each interviewee having one Excel Sheet and each coding unit of the interview occupying an independent row.

To answer the first research question, we tallied the presence and absence of each anxiety theme for each research participant in order to calculate the percent emergence of themes among the 23 Biology GTAs from 2016 and 2017 interviews, respectively. If a transcript contained multiple instances of a theme for the same participant, we only counted it once for that participant. For example, if a participant indicated they were anxious conducting a new statistical analysis for their research because they were not sure how to do it correctly, we would designate that participant as having anxiety related to lack of self-efficacy. After tallying the emergence of each theme among GTA participants, we calculated a total percentage. For instance, if 19 participants indicated anxiety related to lack of self-efficacy, the percent emergence of that theme in the population would be $(19/23) \times 100 = 83\%$. The total percent emergence of each theme for research and teaching anxiety was then compared. In light of the literature suggesting certain subgroups (women, minorities, etc.) experience more anxiety than others (T. M. Evans et al. 2018; George, Saclarides, and Lubienski 2018), anxiety of subgroups of participants were also compared. For these comparisons we looked at gender, ethnicity, and citizenship status (domestic vs. international students).

To answer the second and third research questions (how anxieties changed over one year and how they related to career aspirations), the data were used to create visualizations comparing percent emergence of themes between years and between GTAs who indicated academic vs. non-academic career choices. This was calculated similarly to percent emergence of research and teaching anxiety, except divided into their respective subgroups (2016 vs. 2017 or academic vs. non-academic participants). Figures depicting percent change over time was calculated by subtracting the percent emergence over the year (e.g. difference in percent of participants for each theme from 2016 to 2017). Pseudonyms, aligned with participant's gender and ethnicity, are used throughout the results section.

Methodological limitations

Our study is bounded by the 23 Biology GTAs we interviewed, and their experiences at a particular time (2016-2017). We cannot broadly generalize or claim that these themes would be found in other graduate student populations or at a different time period. However, as the first qualitative study to examine GTAs' anxieties pertaining to research and teaching roles, we hope academic scholars and practitioners responsible for the training of GTAs consider what these GTAs have indicated in our Results as a starting point for their own contexts. As Merriam (1991) argues, the purpose of qualitative research is not for generalization but to capture the essence and phenomenon of what that bounded population is experiencing. We can use the knowledge of these themes to build future surveys to disseminate to a wider population and ascertain if these themes hold true for a larger sample size.

Secondly, since this is a sensitive, often stigmatized topic, we recognize that our sample represents individuals who were comfortable sharing their anxieties, and likely does not represent the whole GTA population. There are existing barriers that individuals face when talking about or reporting anxiety and mental health. Reluctance to seek help and divulge these mental health issues are often attributed to the fear of stigma or expected negative impacts on career aspirations, especially with men (T. M. Evans et al. 2018; OECD 2014).

Results

Five themes characterized teaching and research anxieties among Biology GTAs, but proportions differed by teaching or research role

The interviews revealed five major themes related to GTA teaching and research anxieties across 2016 and 2017 (**Figure 5** and **Table 5**). The first theme, **perception of others and its impact on self,** is the anxiety related to how others perceive your work and judge you as an effective teacher or researcher (**Table 5a**). This theme is concerned with perceptions of the personal consequences (e.g. the GTA's reputation) that may arise as a result of their actions. The percentage of GTAs who articulated this theme was higher for anxiety related to research in both Fall of 2016 and 2017 (91% and 74%, respectively) than for teaching (83% and 57%, respectively) (**Figure 5**). In research, the perceptions of their main research advisor, other faculty, and peers were of most concern to participants. In teaching contexts, the perceptions of students, instructors, and teaching observers were those in which participants were often concerned about. To illustrate this theme, Kaitlyn spoke about how she was anxious

that her students would lose their respect for her if she was unable to answer a student's question:

> *"...being unable to answer the question might affect the students' perception of you…. If their opinion of you becomes lower, they're not going to respect you as much as a teacher." - Kaitlyn (Fall 2017)*

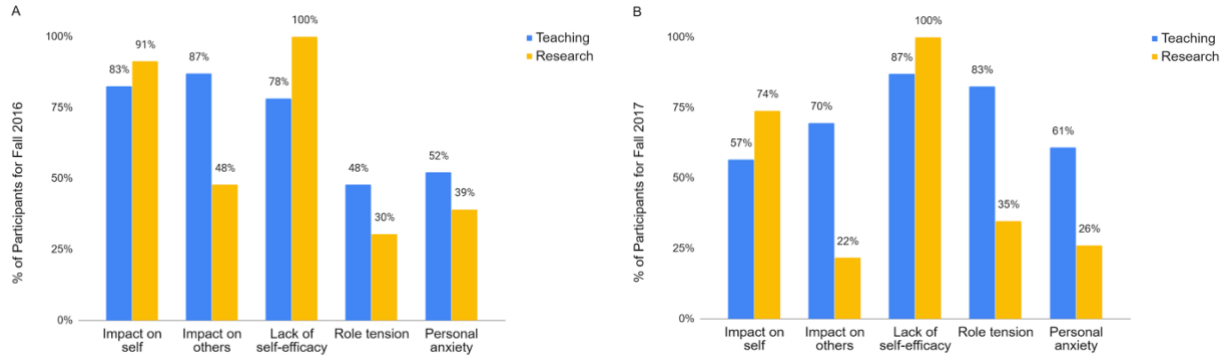


Figure 5. The percentage of participants (n=23) in which each anxiety theme emerged for teaching (blue) or research (yellow), in (A) Fall 2016 and (B) Fall 2017.

Table 5. Major themes (a through e) related to teaching and research anxieties which emerged from interview participants (n=23) from 2016 and 2017. Theme definition and an illustrative quote for teaching and research are included.

Theme	Definition	Teaching Anxiety Quote	Research Anxiety Quote
a) Impact on self (Theme 1)	Anxiety and fear related to how others perceive your work and judge you as an effective teacher/researcher. Anxiety related to the personal consequences of being unable to fulfill the expectations of oneself or others in teaching/research and its reflection on you. This theme pertains to how your behavior may change another person's thoughts of you and hurt you and your reputation. This theme is "you-oriented".	*"…even though I am more comfortable not knowing things, there is still the thought of 'Oh,* ***well this is something you should know****, and* ***they're going to think that you don't know anything****, and* ***you can't teach them if you don't know anything****.'"* - Reagan	*"Normally, I don't care what people think of me, but* ***when it's with my peers, I'm more worried or concerned that they perceive me as someone who is here and serious about doing their research****. I'm always afraid of how I look like when I can't answer a question or mess up on a protocol****.*** *It could make me look like I'm not serious about this."* - Emily
b) Impact on others (Theme 2)	Anxiety of the consequences and impact on others if you are a poor or incompetent teacher/researcher. Participants expressing this anxiety are concerned about how one's actions (or lack thereof) may hurt another person (e.g. student, advisor). This anxiety is distinct from the previous category because it is rooted in how your behavior can hurt another. This theme is "others-oriented".	***"I know that the decisions I make about grading, at least for most students, will affect them and might really make them sad or discourage them****, and you try really hard not to do that, but you also can't just be a pushover about everything. Otherwise, you're not helping the students at all."* -Julia	S: *"I think I just get worried. If I don't know [how to answer a question posed by my advisor],* ***I'll be a disappointment*** *kind of thing and that's one of my worst fears."* Interviewer: *"That people would be generally disappointed or like?"* S: *"Like* ***specifically my advisor*** *and faculty committee people."* -Samantha

Table 5 Continued

c) Lack of self-efficacy (Theme 3)	Anxiety related to the absence of a skill or control in situations of teaching/research. This anxiety is also related to inexperience, uncertainty, and lack of confidence in carrying out a task/handling a situation successfully. Also related to lack of autonomy or knowledge in how to handle a situation or complete a task.	*"Sometimes, **I don't recognize right away what's the best way** I should redirect, or what's the best [teaching] practice I should use. So, when the class redirects and **I feel like I lose control a little bit**, that can stress me out because I feel like I'm trying to quickly redirect and the students pick up on it."* -Lauren	*"I started coming up with my own experiment/ideas. So, it's **uncharted territory** for me and that gives me anxiety. I'm thinking about **'Has anyone done this before? Is there a better way to do this? Is this the right way?'**"* -Emily
d) Role tension (Theme 4)	Anxiety related to lack of time to spend on other perceived priorities, particularly research, course work, and personal life. This theme is typically in the context of teaching taking away too much time from research. Tension in the roles and responsibilities a GTA has in their program.	*"I just feel in the course I'm currently [teaching], **I spend way too much time grading every week, and it takes away from my research**…and I'm just grading really crappy worksheets that aren't really helpful to the students in the first place, and their answers aren't very good because the questions aren't. **It's a lot of time spent on something that's no good for me or for the students**."* -Cathy	*"…pretty much everything that I'm doing, **I'm thinking I should be doing research all of the time**. If I am even doing errands for the lab, I'm thinking: **'I should shove this on someone else, so I can get back to doing my research'**"* -Eric

Table 5 Continued

e) Personal anxiety (Theme 5)	Anxiety and stress related to personal worries or problems. This is often related to lack of finances, paying off loans, politics, religion, etc. This theme often comes up when the "Living off my stipend" card is chosen by participants.	S: "*I like the actual dissection in our [TA] meetings, but **it sucks 'cause it's on Sundays**. Six hours on Sundays…so it's hard to schedule around that. **My girlfriend is 4 hours away, so I usually go on the weekend [to see her] and that takes the option out of the way.** Just being on the weekend kind of sucks."* -Jack	*"So, as a grad student, we all wear a lot of hats …, but I still have a home life - I've got a husband at home that would like me to spend some time with him. I still do the thing where we're sitting on the couch watching TV, but I have my computer open doing work. So, **work/life balance is always a thing I struggled with**, and he realizes this. I'm driving down to a conference with my husband, but he sees this as a vacation - I see it as I've got work from 8am-6pm."* -Laretta

Similar to the first theme, the second theme which emerged among Biology GTAs was **the perception of others and impact on others,** or anxiety in which the GTA is concerned with how their behavior could harm their students, research advisors, or coworkers, rather than themselves (**Table 5b**). This theme occurred more frequently when describing teaching anxieties (87% Fall 2016; 70% Fall 2017) than research anxieties (48% Fall 2016; 22% Fall 2017). The major narrative for this theme involved a GTA's fear of failing to teach a concept competently to their students, thus affecting their students' course grade. For example, Jose explains how he "feels bad" when he fails to properly teach a fundamental concept to his students:

> *"…not being as competent as I would like now, affecting them long-term in the course. Maybe I'm not teaching this part very well, where everything builds upon it. Like the first two-thirds of the course will be based on the first week and a half of material.…Then, you're gonna have problems throughout….Maybe you lose 'em, maybe you confuse 'em...that's even worse."- Jose (Fall 2017)*

The third theme – anxiety rooted in **lack of self-efficacy** – was one of the most predominant themes (**Table 5c**). This theme is characterized by feelings of uncertainty or inexperience towards a teaching/research task, and doubts of self-efficacy, autonomy, or control at a given teaching/research situation. For research, this theme was consistently present for 100% of the GTAs from Fall 2016 and 2017. While not as prevalent, a large portion of the GTAs mentioned this theme for teaching (78% Fall

2016; 87% Fall 2017). This theme commonly appeared when the GTA was required to do a task for the first time alone. For example, Kayla described how she lacked guidance for her field work, therefore she questioned her ability to perform her research properly:

> *"When I was doing field work this season, I usually have to do it by myself. I didn't have anyone helping me, and there are so many times where I was like 'I don't know what this is', but I had to think quickly there, and while I'm doing things, I'm like 'I hope I'm doing this right.'" – Kayla (Fall 2017)*

The fourth theme was **role tension** (**Table 5d**). This anxiety is based on time management issues, often where teaching takes away from other priorities. This theme arose within two different contexts 1) tension between teaching and research responsibilities; and 2) tension between graduate school responsibilities and personal life. For Fall 2016, this theme was relatively moderate for GTAs in teaching (48%) and research (30%); however, in Fall 2017, this theme increased dramatically for teaching (83%) and increased only slightly for research (35%). This theme was most often articulated when participants perceived teaching responsibilities as a lesser priority, and teaching was taking too much time away from research responsibilities. As GTA Rebecca explained, *"I'm not in grad school to teach. I'm in grad school to complete a higher education degree."* Again, illustrating the typical context this theme appears in, Hannah succinctly said:

"I have to spend a lot of time preparing for teaching. That takes away from time doing other activities like research or life." - Hannah (Fall 2017)

The second context for this theme was when graduate school responsibilities interfered with life outside of being a student. In other words, how being a student took time away from being a "normal person," or having a "normal personal life." Anika explained her anxiety over "juggling" all of her priorities as a graduate student, while maintaining a personal life:

"...you have a life outside school, it's not like you can dedicate twenty hours to grad school. So, you want to make sure that you meet your friends and have a social life, but also do research, also write, and ... make your boss happy. So, it's a lot of juggling." - Anika (Fall 2017)

The final theme which emerged related to **personal anxieties** (**Table 5e**). This theme was distinct from the previous theme in that it lacks the time element. These anxieties were personal issues that arose in conjunction with being a graduate student (e.g. finances, politics, religion, familial issues, etc.). For Fall 2016, 52% of participants expressed this theme in teaching and 39% for research. In Fall 2017, 61% of participants indicated it for teaching and 25% for research. In this example from Laretta, she expressed anxiety about the future changes to her family and life that will come post-graduation, including issues of money, geography, and family:

"I think the future is always a scary place … not only with the current funding climate, but trying to figure out where I should transplant my family to- I just got married, and we have so many pets at the house. We just bought a house last year, so what am I supposed to do? Am I supposed to leave my husband and pets at home- do post doc for 2 years and come back? Or bring everyone? Should I rent or sell my house? I don't know. I don't think that it would be difficult for me to find a post doc position, it would be difficult for me to figure out where and how to deal with it." - Laretta (Fall 2017)

When comparing anxieties of different genders, ethnicities, and citizenship statuses within the participant population, we did not find any notable teaching or research anxiety differences between groups in our sample population. These results are included as supplementary figures under the time section below.

Over time, anxieties related to research decreased more than teaching anxieties

One year after the initial interviews, anxieties related to research appeared to decrease more than anxieties related to teaching. There were decreases in 3 research anxiety themes compared to 2 in teaching, and increases in 3 teaching anxiety themes compared with no change or only a slight increase in one research anxiety theme (**Figure 6**). Anxieties related to perception of others and its impact on self or others (Themes 1 and 2) decreased over time for both teaching and research anxiety. However, the change in other themes varied depending on whether it was related to

teaching or research. The anxiety related to lack of self-efficacy increased slightly for teaching (9%), while for research, lack of self-efficacy showed no percent change because 100% of the participants displayed this theme in both interviews (see **Figure 5**). This was the only anxiety which remained above 78% emergence among participants from year to year in both research and teaching. Personal anxiety increased (9%) slightly in teaching contexts and decreased (-13%) in research contexts. Lastly, anxieties related to role tension increased marginally for research (4%); however, for teaching, it increased more over time (35%). Though there were some trends over time among subgroups (e.g. anxieties related to impact on self, impact on others, and personal anxieties of non-white students changed dramatically over one year compared to white students in teaching and research contexts), the small sample sizes make interpretation difficult. We have provided these comparison figures as the Supporting information for reader examination (**Appendix Figures 4-6**).

GTAs pursuing academic versus non-academic careers differed in how research anxieties changed over time

When asked in the second set of interviews if their career aspirations had changed, all GTAs maintained the same primary career aspiration as the previous year. When comparing career aspiration subgroups within years (**Figure 7**), often the most prominent anxiety themes were similar for participants who had academic career aspirations versus participants with non-academic career aspirations (i.e. not working as university or college faculty). Both groups had high levels of anxieties related to impact on self and lack of self-efficacy in teaching and research contexts. In teaching contexts

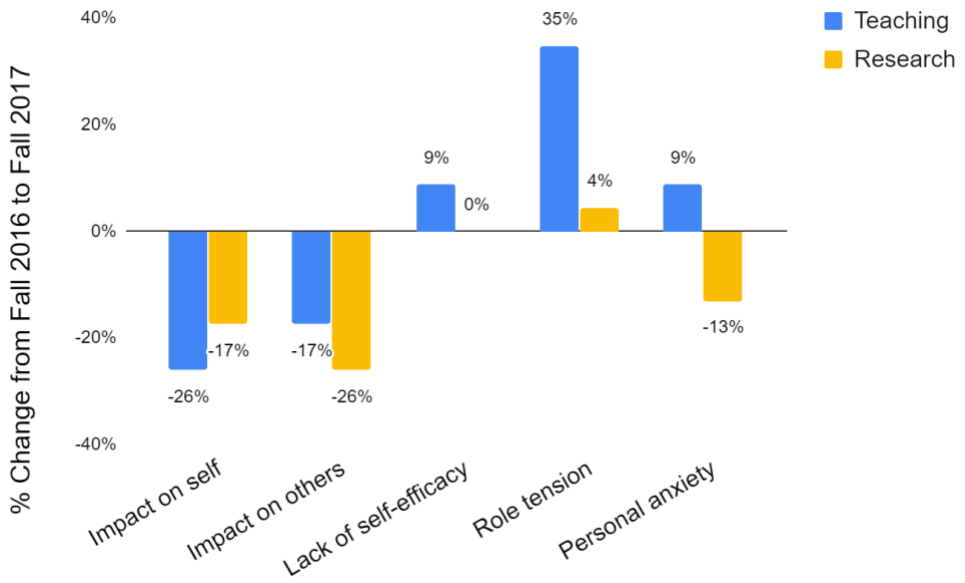


Figure 6. Change in percent anxiety among participants (n=23) from Fall 2016 to Fall 2017 across anxiety themes, separated by teaching (blue), and research (yellow) anxieties.

generally, both career aspiration subgroups had higher anxiety related to impact on others when compared to research. Despite similarities, there were notable anxiety differences between career aspiration subgroups within research contexts. In Fall 2017, GTAs with non-academic career aspirations had higher percentages of anxiety emerge related to role tensions and personal anxieties compared to GTAs with academic career aspirations (**Figure 7d**).

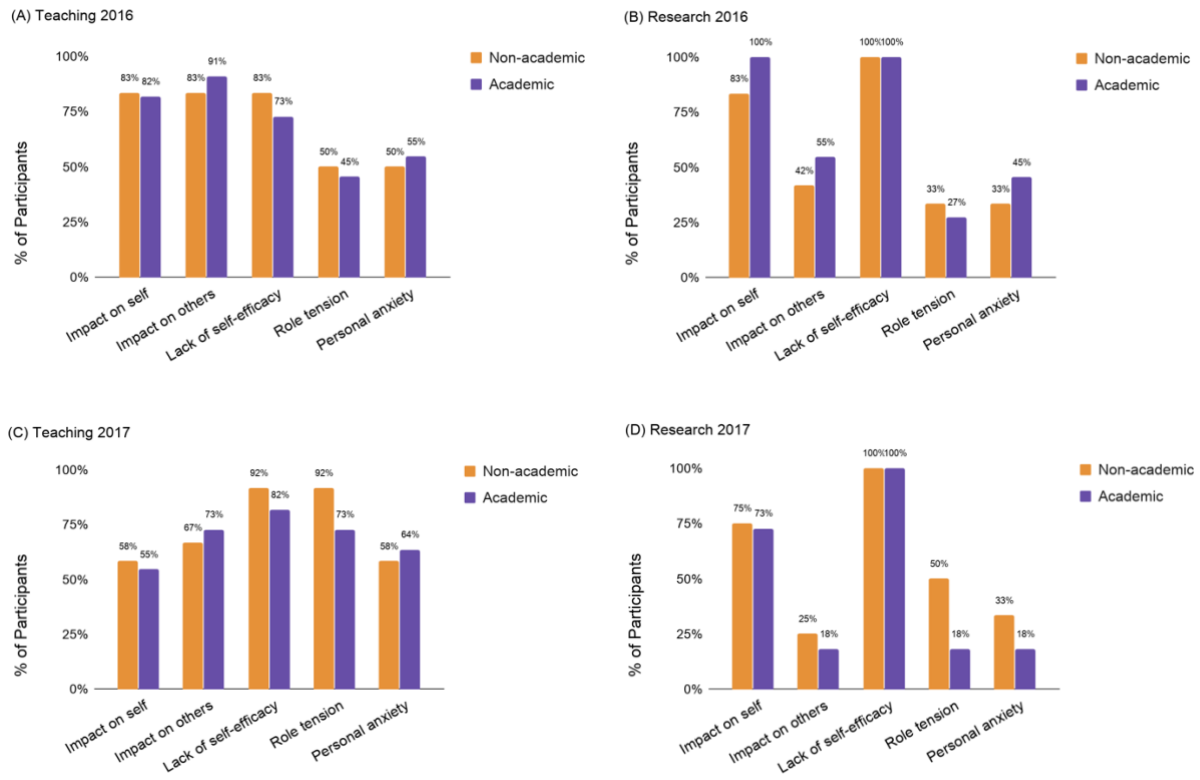


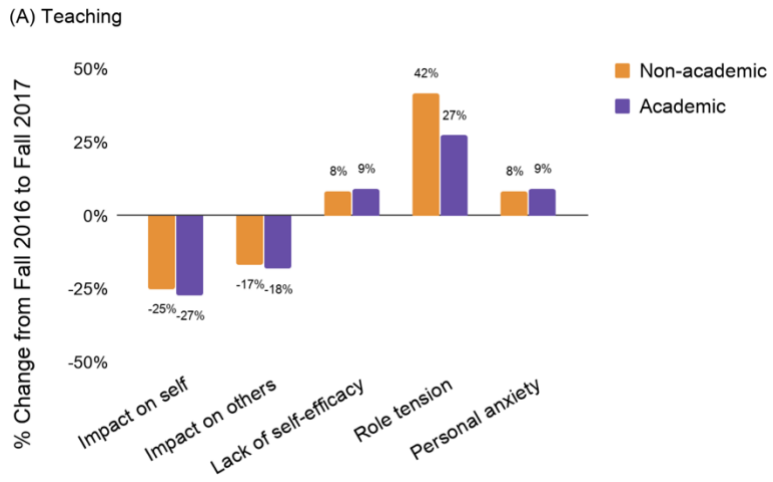
Figure 7. The percentage of participants (n=23) who exhibited each anxiety theme, comparing participants with non-academic (orange, n=12) or academic career interests (purple, n=11), for (A) teaching anxiety in Fall 2016, (B) research anxiety in Fall 2016, (C) teaching anxiety in Fall 2017, and (D) research anxiety in Fall 2017.

When comparing anxiety changes between GTAs with different career aspirations between years (**Figure 8**), trends differed based on teaching and research contexts. In teaching contexts, changes in anxieties over time were similar between GTAs with academic and non-academic career goals (**Figure 8a**). Anxieties related to impact on self, impact on others, lack of self-efficacy, and personal anxiety changed similarly between career aspiration subgroups. Role tension anxiety had the only notable difference between subgroups, with non-academic GTAs having a greater increase in emergence over time compared to academic GTAs. In research contexts,

however, participants with academic career aspirations often had greater decreases in anxiety compared to those with non-academic aspirations (**Figure 8b**). GTAs with academic career aspirations had less anxieties emerge for impact on self, impact on others, role tension, and personal anxiety. Lack of self-efficacy did not change for both career aspiration subgroups (remained 100% of participants) over time.

Discussion

This study took a qualitative approach to probing what underlies anxieties specifically related to teaching and research roles for one group of Biology GTAs, how those anxieties changed over time, and how they compared based on career aspirations. The anxieties which emerged among our Biology GTAs were related to cognitive and background variables on the SCCT model (**Figure 9**). Impact on self (Theme 1) and others (Theme 2), and role tension (Theme 4) are anxieties related to outcome expectations (e.g. *"what will happen to me if I fail to publish my research?"*). Self-efficacy (Theme 3) is a cognitive variable in SCCT. And lastly, personal anxieties



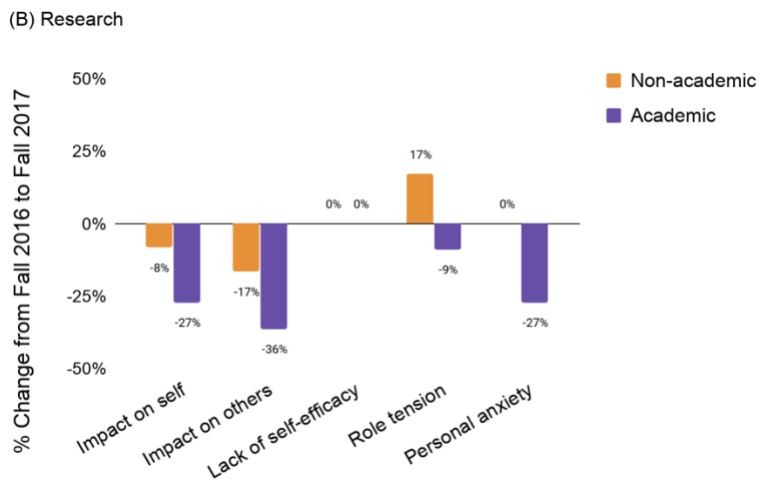


Figure 8. Change in percent anxiety among participants (n=23) from Fall 2016 to Fall 2017 for Teaching (A) and Research (B) anxiety between non-academic (orange, n=12) and academic (purple, n=11) career aspirations.

(Theme 5) are related to SCCT's background environmental or contextual variables. We found that teaching anxieties were most often related to a GTA's perceived impact on others (e.g. students), while research anxieties were related to lack of self-efficacy. Role tension for teaching increased over time, while lack of self-efficacy was uniformly high over time for research. Interestingly, GTAs with academic career aspirations seemed to have less anxieties related to research over time. This indicates that discussions of graduate student anxiety may need to consider the different roles of GTAs separately, in combination, over time, and with career aspirations in mind to gain a more nuanced understanding of GTA well-being.

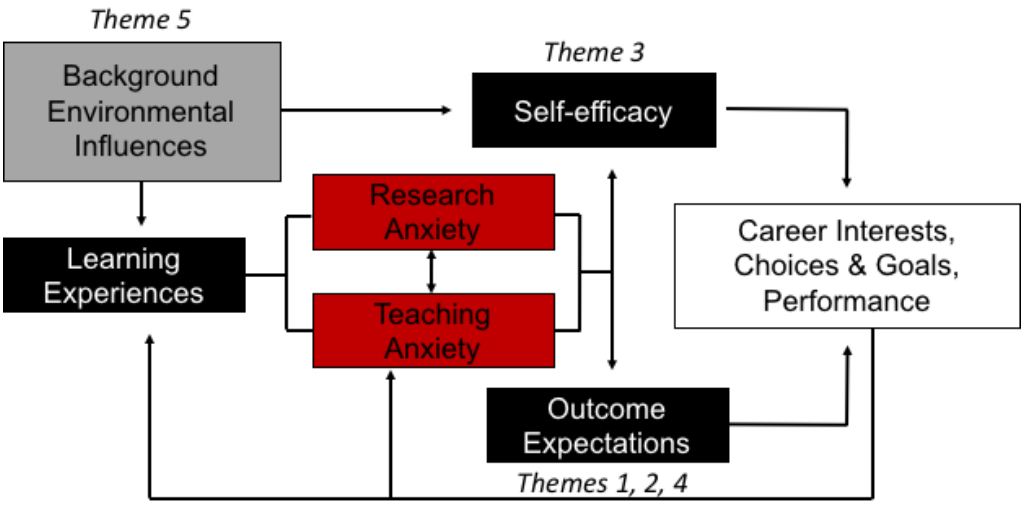


Figure 9. Modified Social Cognitive Career Theory (SCCT) model mapping the five anxiety themes found in this study with the cognitive and contextual factors which influence career interest development. Anxiety themes related to impact of self, impact on others, and role tension (Themes 1, 2, 4) were associated with outcome expectations, what GTAs expected to come out of certain professional interactions or decisions. Anxiety related to lack of self-efficacy (Theme 3) was related to a GTAs self-efficacy for a task and the perception that they could not complete it successfully or had no control to do so. Lastly, personal anxieties (Theme 5) are related a GTAs background influences such as departmental culture or personal life.

Perception of others impacts GTA anxiety toward teaching and research

The perceptions of others, especially doctoral advisors and undergraduate students were related to two of the themes we identified in this study and is likely an important component of anxiety. Graduate school is not conducted in a void; students are constantly interacting with students, peers, and faculty and these interactions can influence how novices gradually adopt the identity of the profession (Adler and Adler 2005). It is no surprise that in these interactions are embedded fears of being covertly evaluated or compared (Adler and Adler 2005). Receiving positive feedback, recognition, and respect from faculty, peers, and students marks progress in graduate school socialization and likely impacts anxiety changes over time. Mentors, especially

doctoral supervisors, play an integral role in successful socialization and sense of belonging to their mentees (McConnell, Geesa, and Lowery 2019). The student-advisor relationship is often the most important predictor of the satisfaction and persistence of a student's doctoral experience (Devos et al. 2017; Hish et al. 2019; Hunter and Devine 2016; Zhao, Golde, and McCormick 2007), and influences the formation of a graduate student's professional identity, the quality of their dissertation, professional network development, and available job prospects (Lovitts, 2001). Positive support and feedback from graduate students' mentors can help bolster self-efficacy in teaching and research, helping them socialize into their professional identity. As Golde (2000) points out in studying graduate student experiences: "pivotal in each story was the importance of a supportive advising relationship in helping students making progress toward their degree." (p. 219). In general, we found anxieties related to perceptions of others and its impact on self, decreased over time. It is possible that with successful socialization, GTAs may have less anxiety over how others perceive them. However, difficulties in socialization would be expected to increase anxiety.

While the research anxiety related to perception of others was predominantly directed towards advisors, in a teaching context, this anxiety often related to undergraduates. GTAs focused on not letting down their students and establishing positive perceptions of themselves with their students. In many cases, GTAs may feel they need to work harder to establish their credibility in the classroom compared to faculty (Golish 1999; Hendrix 1995). In studies examining undergraduate perceptions of GTAs versus faculty, undergraduate students rated faculty members higher initially for being confident, enthusiastic, with more authority over the curriculum; while GTAs were

rated higher for being nervous, uncertain, but having a more enjoyable instructional style (Kendall & Schussler, 2012; Kendall & Schussler, 2013). GTAs in this study often indicated a fear of improperly or accidentally conveying incorrect information to their students, thus negatively impacting their students' learning. By providing teaching professional development opportunities, supportive preparatory meetings, or a system for structured teaching feedback, particularly for novice GTAs, teaching self-efficacy may increase, leading to reductions in anxieties related to perception of others.

Self-efficacy may be critical in reducing anxiety

Lack of self-efficacy (Bandura, 1988) was most one of the most prominent anxieties among GTA participants for both teaching and research contexts, emerging often and consistently over time in this study. This comes as no surprise, as Bandura (1988) and others (Connolly, Lee, and Savoy 2018; DeChenne et al. 2015; Reeves et al. 2018) established that if self-efficacy for a task is high, then the anxiety toward said task is low. With forty percent of our Fall 2016 Biology GTA sample being first year GTAs, we may infer that self-efficacy may have been low for many of these students. Low self-efficacy occurs often with doing tasks such as teaching or doing research for the first time (Adler and Adler 2005). Several of the GTAs mentioned tasks being done for the first time in their interviews when asked to explain their anxieties.

Despite an expectation that self-efficacy may increase over time in graduate students, anxieties related to lack of self-efficacy or control for both teaching and research did not change over the year. In teaching settings, this can sometimes be related to a perceived lack of authority or autonomy of GTAs in the way a class or

module is organized and taught (Muzaka 2009). Some GTAs also commented that they felt their voice in the organization, running of classes, and related issues was not important. Teaching assignments for graduate students are also not always stable. GTAs can be moved around to teach different courses, requiring new class or lab preparation. Research projects also change over time, requiring the learning of new skills at different stages of a project. In research, lack of self-efficacy over time may be attributed to part of this socialization process, where at different stages of the doctoral program, new tasks are encountered and self-efficacy must continually be built (Adler and Adler 2005; Gilmore et al. 2015). In the teacher education literature, a curvilinear relationship in teaching self-efficacy has also been observed, where inexperienced GTAs initially have a higher level of teaching self-efficacy compared to those teachers with a slight amount of experience, eventually leading to higher levels of efficacy as experience grows (Prieto and Altmaier 1994). This phenomenon may be attributed to the initial absence of actual teaching experiences, temporarily inflating perceived teaching self-efficacy, until teachers acquire real teaching performance accomplishments (Dembo et al. 2017; E. D. Evans and Tribble 1986; Prieto and Altmaier 1994). To build lasting teaching self-efficacy in GTAs, departments could make teaching assignments more stable over time, unless a GTA requests otherwise. To build research self-efficacy, advisors, departments, and institutions should consider how to better develop transferable skills in students, rather than having students fend for themselves (Hancock and Walsh 2016; Sinche et al. 2017). Providing resources or programmatic interventions (Sinche et al. 2017) can go a long way to minimizing anxieties and supporting graduate students with a wide range of careers interests.

Biology GTAs struggle with prioritizing research versus teaching resonsibilities and work-life balance

Tension between a GTA's responsibilities in teaching and research are another point of anxiety, particularly related to time constraints. These tensions have been reported in previous work examining doctoral student's perceptions of teaching, and in the development of GTA professional identity (Gilmore et al. 2015; McAlpine, Jazvac-Martek, and Hopwood 2009; Muzaka 2009). When Muzaka (2009) surveyed 10 GTAs and their perceptions of the most beneficial and problematic aspects of teaching, they found that the difficulties often related to time pressure. The majority of GTAs commented that teaching took considerable time away from their research and could delay timely graduation of their doctorate (Muzaka 2009). When McAlpine and colleagues (2009) studied Canadian Education doctoral students and their formation of academic identity, students reported that conducting research could pose difficulties in terms of the time available to do their work. These findings are echoed in our Biology GTAs, which suggests that tensions between roles and responsibilities are to be expected within the socialization and formation of professional identities in graduate school.

It should be noted, however, that investing time in pedagogy through teaching professional development (TPD) programs, may actually be beneficial for research preparation (Shortlidge and Eddy 2018) and does not delay graduate student time to graduate (Connolly et al. 2016). Gilmore and colleagues (2015) found that among the graduate students (n = 223) they surveyed, GTAs indicated a complimentary

relationship between teaching and research (Gilmore et al. 2015). It is important for institutions to message to their students that teaching and teaching training can be incorporated into graduate programs without reducing students' preparedness for a research career, and help students to see that these roles are not necessarily in conflict.

Lastly, personal anxiety (Theme 5) was expressed by many students in this study. According to a recent survey of over 6,000 graduate students, doctoral students hold great fears related to uncertainty of job prospects and difficulty maintaining a work–life balance (Woolston 2019). Hish et al. (2019) also found that personal anxieties (family and monetary stressors) correlated to depressive symptoms. Again, the process of graduate students' socialization is not completed in isolation, nor can it be separated from a student's personal life outside of the workplace. To encourage better school-work-life balance for students, doctoral advisors can model healthy role balances and flexibility in school and work schedules; while doctoral programs can continue to provide financial support, and support services tailored to specifically address doctoral student needs (Martinez et al. 2013; McConnell, Geesa, and Lowery 2019).

Anxieties towards research declined over time for GTAs pursuing academic career aspirations

Though this was not a quantitative study, we found that individuals who wanted to pursue academic careers seemed to have a decline in anxiety pertaining to research by Fall 2017. As part of the socialization process (Adler and Adler 2005; Austin and McDaniels 2006; Lindholm 2004) and as expected from the SCCT model (Lent, Brown, and Hackett 1994), GTAs seemed to acclimate to the demands of academic research

more easily if they were interested in a career in academia. As we found, with positive outcome expectations and learning experiences related to research, GTAs with academic career goals had overall fewer anxieties regarding research, despite lack of self-efficacy remaining a predominant factor related to anxiety. These GTAs also had some decreases in teaching anxieties. Over the span of their programs, STEM doctoral students often develop more interest in teaching undergraduate students, alongside their research interests, making teaching a predominant occupation (Connolly et al. 2016). Our GTAs who indicated a desire to pursue academia often included both a research and a teaching interest. Budding teaching interests could be related to decreases in research and teaching anxiety, as GTAs become more proficient in their research and teaching roles.

The changes in anxiety over time for GTAs with non-academic career aspirations reveal a more complex narrative, with no clear changes in anxieties over time. Surprisingly, the types of non-academic career aspirations listed by GTAs often included research in non-academic settings (e.g. government, industry, non-profit), suggesting that their anxieties in research could be specific to the academic research setting versus research in other contexts. Anxieties related to role tension increased among these GTAs, which can be expected if a GTAs is grappling with how to acquire the necessary skills to pursue their non-academic career interests which may not include teaching. Anxieties in teaching and research for GTAs with non-academic goals may be further exacerbated due to lack of departmental support in attaining these “non-traditional” career goals. O’Meara et al. (2014) found that departments can positively influence student agency by encouraging multiple career paths, providing information

and financial support, and offering mentoring and guidance. By having advisors and departments support the formation and success of non-academic career paths for GTAs, anxieties for graduate students who want to pursue a non-academic career may be reduced.

Improving GTA well-being: Building self-efficacy and coping strategies

A recent report by the National Academies of Sciences (2018) recommended that institutions and departments provide stronger support for graduate student mental health services. This call to action requires further in-depth research on the causes of graduate student mental health issues, so institutions and departments may make more informed decisions about *what* aspects of their programs may cause anxiety, *how* to support their graduate students at various points in their program and *which* graduate students need the greatest support. This work could inform these decisions and help identify groups (e.g. GTAs pursuing non-academic career paths) who may be more negatively impacted by anxiety and offer insight as to the most effective strategies of coping to alleviate destructive anxieties.

There are several ways graduate student well-being can be improved throughout their program. Through professional development opportunities, stress management techniques, teaching self-compassion, gratitude journaling, effective and supportive advisor mentoring, or encouraging counselling, academia can be a place for graduate students to maintain well-being (DeChenne, Enochs, and Needham 2012; Flinchbaugh et al. 2012; Golnaraghi 2016; National Academies of Sciences Engineering and Medicine 2018; Nicklin, Meachon, and McNall 2019; Reeves et al. 2018). For example,

introducing coping strategies in new graduate student orientations or professional development may help to reduce anxieties from the outset. Byers et al. (2014) found five major themes emerge during their interviews on survival strategies for doctoral students: compartmentalization of life, outside support systems, justification for participation in program, emotional status, and structure of program (Byers et al. 2014). By emphasizing to graduate students, especially incoming novice graduate students from both Master's or Doctoral programs, that these aspects may help one maintain mental health, we can improve the graduate student experience and reduce attrition of vulnerable groups from academia.

Limitations: Not all anxiety is equal

Similar to previous studies in this research group (Chen and Schussler, in revision), this research may lead the reader to assume that anxiety is not desirable, and negatively impacts an individual's well-being and daily life functioning. However, we acknowledge that not all anxiety has the same effect, and that some anxiety can actually be a positive force for productivity and creativity. Yerkes and Dodson (1908) established that there is an ideal threshold in which "arousal" or anxiety can actually increase productivity (Cohen 2011; Pelton 2014). Too much and too little anxiety are both likely impediments to achievement, and to a certain extent, some level of doubt or lack of confidence may provide significant impetus to improving effectiveness such as in teaching (Wheatley 2005). Though we recognize some anxiety as motivating, anxiety can only help individual well-being if positive coping strategies are present. Therefore, for the future, to distinguish between negative and positive anxieties, we hope to

additionally examine how individuals cope with each anxiety. If the coping is constructive and effective, anxiety may actually be productive. If the coping involves avoidance and is destructive, that anxiety may have a negative impact. By examining these anxieties in a longitudinal framework, we can also investigate whether coping and anxiety becomes more or less productive over time.

Conclusions

To tackle the graduate student anxiety epidemic, there must be a better understanding of what makes students anxious in order to propose methods to reduce that anxiety. This study provided an important first step to help understand how others in the academic context, self-efficacy, and personal perceptions play a role in mental health. In some cases, the anxieties students expressed such as role tension or work-life balance may be symptomatic of systemic structural problems in academia that will be hard to change. However, professional development activities or training opportunities for GTAs pose a tangible, effective method for institutions and departments to consider mitigating anxiety. Professional development workshops may also provide efficacious coping strategies to regulate external stressors which cause anxiety and encourage greater sense of community. In this way, universities can start to take responsibility for not only training graduate students in the academic discipline, but also helping them navigate the cognitive and emotional outcomes that are a common part of seeking a higher degree.

CHAPTER III

TO COPE OR NOT TO COPE? CHARACTERIZING BIOLOGY GRADUATE TEACHING ASSISTANT (GTA) COPING WITH TEACHING AND RESEARCH ANXIETIES

Abstract

In the United States, one in three graduate students report being depressed, and anxiety in academia is widespread. To manage anxieties, graduate students can employ coping strategies. Coping is an individual's behavioral and cognitive response(s) to external stressors, often with the goal to reduce or tolerate the stress. Adaptive coping strategies advance individuals through problems and support their well-being, while maladaptive coping strategies prevent stressors from being resolved and can threaten well-being. Previous research has indicated that anxieties related to the teaching and research roles of graduate teaching assistants (GTAs) differ, and this study investigated whether the coping strategies for each role differ as well. We interviewed 23 Biology Graduate Teaching Assistants (GTAs) at a research-intensive university about how they coped with teaching and research anxieties in 2016 and in 2017. We also compared coping strategies among GTAs with academic versus non-academic career aspirations. The 12 major families of coping proposed by Skinner et al. (2003) were used to analyze interview transcripts. Biology GTAs often used adaptive coping strategies, rather than maladaptive strategies to manage teaching and research anxieties. To cope with teaching anxiety, GTAs more often used problem solving and information seeking. To cope with research anxiety, problem solving, information seeking, and support seeking strategies were used most often. Over time, these adaptive coping strategies declined in use among the GTAs, however, maladaptive strategies did not notably increase. This may indicate that GTAs are learning the best ways to cope, and thus stabilizing their coping approaches to manage anxieties over time. GTAs with both academic and non-academic career goals predominantly relied on

adaptive coping strategies, although GTAs with academic career aspirations tended to have less fluctuations in coping over a year compared to GTAs with non-academic career aspirations. In understanding how GTAs cope with teaching and research anxieties during their degree programs, this work can inform professional development for GTAs, convey the use of specific adaptive coping strategies to graduate students, and encourage greater awareness and dialogue about GTA mental health issues in academia.

Introduction

Graduate school—a time dedicated to the development of scholars in a disciplinary area—marks the start of an arduous mental health journey for some students. Graduate students have been reporting high levels of anxiety, affecting their overall mental health and attrition in graduate programs (T. M. Evans et al. 2018; Levecque et al. 2017; Rummell 2015). For example, Rummell (2015) surveyed 119 psychology graduate students, and found that about 49% experienced clinically significant anxiety, with 35% reporting symptoms that aligned with both anxiety and depression. Though graduate student mental health issues are starting to be explored at greater depth (Woolston 2019), identifying what contributes to graduate student anxiety and how students cope with these emotions remains in its infancy.

This study will investigate the construct of anxiety specifically, and not related constructs such as stress or depression or burnout. Anxiety is a commonly-experienced emotion in academic contexts because it is linked with achievement activities and outcomes (American Psychological Association 2020; Pekrun et al. 2007). For the

purposes of this paper, we will be using Bandura's (1988) definition of anxiety, which states anxiety as feelings of stress, concern, or apprehension over an anticipated outcome or event.

Graduate students report anxieties related to teaching and research roles

Our previous work (Chen Musgrove, Petrie, Schussler, in review) qualitatively explored the anxieties related to two important roles of Biology Graduate Teaching Assistants (GTAs): teaching and research. We identified five major anxiety themes—anxieties related to actions impacting self, actions impacting others, lack of self-efficacy, role tension, and personal anxieties. The most prevalent anxiety in research contexts was a lack of self-efficacy, or lack of belief in one's ability to carry out a required task as a researcher. Although this theme also emerged for teaching contexts, teaching anxieties were associated more with concerns about negatively impacting their students' academic success. These distinct anxieties which emerged among Biology GTAs may be rooted in the graduate student socialization experience, particularly in balancing teaching and research responsibilities and in assessing the relative value of each to future career prospects.

Socialization is the process by which an individual joins and integrates into a community, group, or organization (Austin and McDaniels 2006; Corcoran and Clark 1984; Van Maanen 1976; Staton and Darling 1989). During graduate school, doctoral students experience several socialization processes: socialization to the academic life, the academic profession, and to a specific discipline or field (Austin 2002, 2003; Austin and McDaniels 2006; Golde 2005; Van Maanen 1976). Academia as a professional

institution requires individuals to integrate multiple professional roles, e.g. teachers, researchers, students, and employees (Kajfez and Matusovich 2017b; Kajfez and McNair 2014), and part of a graduate student's socialization into academia is learning to balance these multiple roles. For new graduate students who are teaching for the first time and establishing new research projects (and often also taking courses), the time demands of each role can create anxiety (Chen Musgrove et al., in review). Adding to these emotions are implicit or explicit messages about the relative value of each role and where to place graduate student effort regardless of personal preference (Lane, Hardison, et al. 2019). Thus, graduate student socialization can be associated with significant mental health impacts over time.

In academia—a workplace that can demand long hours, routine rejection, and uncertainty—coping strategies must be learned, and can thus change over time as graduate students progress in professional socialization. With more experience mastering and practicing tasks in graduate school, especially research and teaching related responsibilities, GTAs may build better coping skills to manage anxieties. Institutions which employ graduate students should be invested in maintaining positive mental health of these students, as universities rely their functioning in teaching and research roles. Nationally, over 91% of freshman Biology labs and discussions are taught by Biology GTAs (Sundberg, Armstrong, and Wischusen 2005). Institutions and faculty also rely on successful research output (e.g. publications) of graduate students (National Academies of Sciences Engineering and Medicine 2018). Being able to cope with existing anxieties is essential not only for daily functioning of our graduate students, but also supports academia more broadly. If graduate students learn to employ effective

coping strategies when anxious in teaching and research contexts, we may reduce the student attrition rates of (30-50%) out of their programs (Levecque et al. 2017).

GTAs can cope using adaptive or maladaptive strategies

Coping is essential for positive individual mental health and well-being. Coping can be defined as an individual's behavioral and/or cognitive response(s) to external stressors, often in an attempt to reduce or tolerate the stress (Carver, Scheier, and Weintraub 1989; Lazarus 1993; Shin et al. 2014; Skinner et al. 2003). Coping has been organized into several broad categories; all with the intent to capture similarities or differences of an individual's response towards stressors or its outcomes. In an extensive review on coping strategies, Skinner et al. (2003) reported on several "top-down" or overarching coping categories, such as problem-focused vs. emotion-focused coping, approach vs. avoidance coping, and adaptive vs. maladaptive coping (Horowitz, Wilner, and Alvarez 1979; Lazarus and Folkman 1984; Roth and Cohen 1986). Skinner et al. (2003) proposed that to best understand coping, we need to combine existing broader categories of coping with a more inductive, context-specific approach. To this end, they developed 12 sets of coping families which "*characterize existing coping strategies based on the key role actions can play in bridging the conceptual space between coping instances and adaptive processes."* For example, if an instructor coped with anxiety giving lectures by preparing notes and practicing, this would be an example of the problem solving family of coping. This strategy is an approach-oriented, problem-focused, adaptive strategy, in which anxiety is effectively managed. Conversely, if the instructor were to instead run away from lecturing by giving the task to a colleague, then

that coping approach would fall in the escape family. This category of coping may be considered an avoidant, emotion-focused, maladaptive response, meaning it does not effectively reduce or manage anxiety. These 12 families are designed to represent a wide variety of coping strategies. We will use the 12 families, as well as their organization into *adaptive* or *maladaptive* approaches, in this study.

Adaptive coping helps individuals successfully progress through problems and supports their well-being. Approach-oriented, adaptive coping can lead to positive increases in self-efficacy and reductions in anxiety (e.g. practicing for a presentation, seeking advice from a mentor). The use of maladaptive coping prevents problems from being solved and can threaten an individual's well-being. Avoiding writing tasks, social isolation, ruminating on negative outcomes are some examples of this type of coping. Lastly, Henry et al. (2019) and Skinner et al. (2003) also identified "in-between" coping strategies, which may be considered adaptive or maladaptive based on the context in which the coping strategy is used and implemented. For example, distraction is a type of avoidance coping, however, it may be used effectively to take breaks from a work task, assuming the individual returns to engage in the task. According to the Lazarus Transactional Model of Stress and Coping, short periods of avoidance coping can be physiologically beneficial to an individual, especially for uncontrollable situations, so long as the coping transitions into strategies which are approach-oriented (Bandura, 1988; Lazarus & Folkman, 1984). It is important to note that the effectiveness of a coping strategy is based on successful anxiety management, regardless of what is perceived as "good" or "bad" coping strategies, and what works for one individual may not work for someone else.

Previous studies examining general coping of graduate students found they used both adaptive and maladaptive coping approaches (Chang & Edwards, 2015; El-Ghoroury, Galper, Sawaqdeh, & Bufka, 2012; Kjerulff & Wiggins, 1976; Nelson, Dell'oliver, Koch, & Buckler, 2001). For example, Nelson et al. (2001) modelled stress, coping, academic success, and relative health in 53 clinical psychology students, and found adaptive coping strategies were helpful moderators of stress. Graduate students with higher grade point averages were more likely to utilize coping styles characterized by less denial, more religious coping, more venting and expressing emotions, and greater seeking of instrumental emotional social support (Nelson et al., 2001). Often the greatest stressors reported by these students were either from research contexts (e.g. scholastic coursework and dissertation work) or personal and career contexts (e.g. financial finding internships or work after school, practicum placement, daily hassles, time management and availability, and work with clients).

Theoretical framework: The Social Cognitive Career Theory (SCCT)

The Social Cognitive Career Theory (SCCT) provides a theoretical framework for studying the role coping and anxiety play in future faculty (**Figure 12**). The SCCT identifies and maps the contextual, cognitive, and behavioral variables which influence a person's career interests and trajectory (Bandura, 1993; Lent, R. W., Brown, S. D., and Hackett, 1994). These variables include *learning experiences* (e.g. teaching in a classroom or conducting data analysis) *self-efficacy expectations* (e.g. "Can I teach/research well?") and *outcome expectations* (e.g. "What will happen if I teach/research poorly?"). These variables are dynamic; they change depending on a

GTAs experience and perceptions, and thus the inputs and their outcomes can change over time. With this framework, we would expect that both coping, and anxiety will impact these cognitive variables to subsequently influence career interest, choices, and performance.

For our study, we have modified the original SCCT model (see red boxes in **Figure 10**), to add teaching anxiety, research anxiety, adaptive coping, and maladaptive coping. Teaching and research anxieties would be strengthened or weakened as a result of an individual's *learning experiences* and would therefore influence the cognitive variables of *self-efficacy* and *outcome expectations.* These variables would go on to influence coping, where we expect that a GTA's coping ability will subsequently impact career-related choices and performance in teaching (e.g. positive classroom experience) or research (e.g. successfully publishing). Coping can be viewed as effort and progress toward a goal (Chang and Edwards 2015). For example, let's say a GTA was anxious about his student's class satisfaction, and coped by ensuring students had all necessary resources for studying (i.e. coping through problem solving). If at the end of the semester he received mostly positive student evaluations from his teaching, it would provide evidence that his coping strategy helped him to successfully progress toward his goal of teaching well. It would also help to minimize his previous teaching anxieties. Therefore, the strength of a GTA's coping can determine how teaching and research anxiety further mediates between *learning experiences* and *self-efficacy/ outcome expectations*. In **Figure 10**, we show where graduate student teaching anxiety and research anxiety would best fit in the SCCT model. For the purposes of this study, we will be focusing on characterizing coping to teaching and research anxiety in Biology

graduate teaching assistants (GTA).

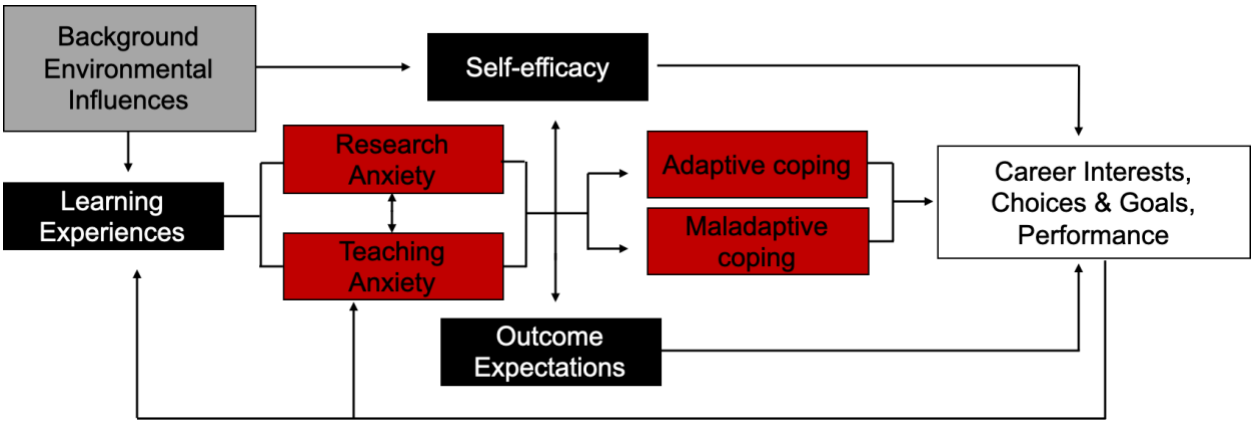


Figure 10. Modified theoretical model from the Social Cognitive Career Theory (SCCT), specifically for careers that are geared towards academic or non-academic goals. The SCCT aims understand the multiple components which contribute to how career interests, choices, and goals develop. The grey box indicates influencing background or contextual components, the white box indicates the career outcomes, and the black boxes are the main drivers that contribute to career development. Additional components of anxiety and coping can be found in red boxes. Teaching and research anxiety would impact self-efficacy and outcome expectations, which are strengthened or weakened as a result of learning experiences. The strength of a GTA's coping would then determine how a GTA progressed towards career goals and performance, and also impact how much anxiety would influence self-efficacy and outcome expectations.

Using SCCT as a framework also allows us to explore how GTAs with different career aspirations may cope during graduate school. During their program, GTAs are balancing multiple roles which may or may not align with their career interests, contributing to a graduate student's anxieties (Adler and Adler 2005; Sverdlik and Hall 2019; Winstone and Moore 2017). Not all graduate students hold academic career aspirations, to which they are all being trained for in research-intensive graduate programs (Fuhrmann et al. 2011). This misalignment with a graduate student's career goals and their programmatic training may lead to greater or lesser affinities for particular roles such as teaching or research (Goetz et al. 2013b; Kajfez and McNair 2014).

Rationale for our study

Biology GTAs are anxious about teaching and research, and their anxieties can also differ depending on their career trajectories (Chen Musgrove et al., in review). However, we do not know how GTAs are coping with these teaching and research anxieties, how coping strategies might change over time, and how they may differ based on career aspirations. As part of a longitudinal study, this study seeks to investigate how a sample of Biology Graduate Teaching Assistants (GTAs) cope with teaching and research anxieties at a large research-intensive southern university. To our knowledge, this is the first qualitative study to examine Biology GTA coping to teaching and research anxieties.

We investigated coping strategies specific to teaching and research anxieties in a sample of 23 Biology GTAs. To judge whether these strategies changed over time, we

interviewed the same group of GTAs twice over one year (Fall 2016 and Fall 2017). Our research questions were three-fold:

(1) How do Biology GTAs cope with teaching and research anxieties? How do the strategies used for teaching and research compare?

(2) How do Biology GTA coping strategies change over one year?

(3) How do Biology GTAs with academic vs. nonacademic career aspirations differ in their coping to teaching and research anxieties?

Methods

Study population

Biology GTAs at a large research-intensive southeastern university were our study population (IRB-16-03235-XP). The GTAs were recruited via email from across three Biology departments and one program in the Division of Biology. As of Fall 2016, 211 graduate students in these units were enrolled in a Master's or Ph.D. program, with 94% of graduate students seeking Ph.D.'s, 55% identifying as female, and the majority being white.

Data collection

In October 2016, an online survey was deployed to Biology graduate students via the Qualtrics survey software. The e-mail recruited individuals who were either currently teaching or who had been a GTA previously. This survey collected quantitative data for another study (Chen Musgrove and Schussler, in review), but was also used to recruit participants for this qualitative study. Of the 89 Biology GTAs who completed the

survey, 26% (n = 23) indicated that they would be interested in participating in follow-up interviews.

Interviews of graduate students were conducted twice over one year to collect in-depth perceptions of how GTAs coped with teaching and research anxiety, and whether their strategies changed over the year as they socialized into their programs. From the Fall 2016 survey, we collected participants' gender, ethnicity, citizenship status (international vs. domestic), teaching experience (number of semesters as a GTA), age, degree program, year in the graduate program, and department affiliation. GTAs in the interview pool were 70% female, and 74% white (see **Table 6** for demographics). All interviews were conducted by the first author (M.C.M.). Each interview was ranged between 60-90 minutes long. Participants were given a small monetary compensation of $10 per interview, which was disseminated onto their student card after the interview was complete.

Table 6. Demographics of the 23 Biology GTAs interviewed in 2016 and 2017.

	n	**% of total participants (n = 23)**
Gender		
Male GTAs	7	30
Female GTAs	16	70
Citizenship Status		
Domestic	17	74
International	6	26

Table 6 Continued

Ethnicity	18	78
White	5	22
Non-white		
Experience level		
Novice	10	43
Experienced	13	57
Career aspirations		
Academic	11	48
Non-academic	12	52
Degree		
MS	4	17
PhD	19	83
Year in Program		
1	9	40
2	7	30
3	7	30
Department		
BCMB	2	9
EEB	12	52
GST	3	13
Micro	5	22
Other	1	4

***** *Experienced GTAs = >1 year of GTA experience; Novice GTAs = <1 year of GTA experience*
****** *BCMB = Biochemistry & Cellular and Molecular Biology; EEB = Ecology & Evolutionary Biology, GST = Genome Science & Technology, Micro = Microbiology*

Biology GTA Interviews

Interviews were conducted with the same 23 graduate students in Fall 2016 and again in Fall 2017 using the same interview protocol (see Appendix) with the addition of

a few retrospective questions in 2017. Interview questions probed four main topics: (1) a GTA's perception of their experience level in teaching, knowledge of teaching, and effectiveness in teaching; (2) their teaching and research anxieties; (3) coping strategies enacted for each anxiety; and (4) their professional identity/career aspirations as teachers and researchers. To probe the second and third topics, card sorts (see Appendix) were used as a tool to guide conversations about teaching and research anxiety and coping. Card sort activities help to make abstract concepts more tangible for participants, especially as interactive, object-based aids to qualitative interviews (Conrad & Tucker, 2019). For these interviews, one set of cards contained hypothesized factors or situations that may relate to teaching anxieties (e.g. student behavior, grading, etc.) and the other set contained hypothesized factors related to research anxieties (e.g. publishing, data analysis, etc.). Blank cards were also available for participants to write their own factors not captured by the existing cards. The interview protocol and card sort items were vetted by 2 faculty members (both trained Biologists and Education Researchers), one Biology education post-doctoral researcher, and two Biology graduate students.

Before reading the cards, participants listed any teaching and research anxieties they experienced on a blank piece of paper. All participants indicated some anxiety. Participants then read the cards, picked relevant anxiety cards for teaching and research, respectively, and ranked them from greatest to least anxiety. They then explained what about the factor on the card made them anxious, the perceived impact of this anxiety on their teaching or research, and how/if they coped with that factor. Participants often added anxieties not already on the cards.

Data analysis

Interviews were audio-recorded and transcribed in order to conduct qualitative content analysis to identify *a priori* themes. For this analysis, only the portion of the interviews about coping with anxieties in 2016 and 2017 was used. Using the coping families listed by Skinner et al. (2003) as a working codebook, *a priori content coding* was conducted on the interview data corpus (Charmaz, 2006; Saldaña, 2012; Strauss & Corbin, 2008). In *a priori* coding, researchers use an existing codebook, and identify and categorize participant ideas within those given themes (Saldaña, 2012). Even with an established coding scheme, qualitative content analysis still requires careful, iterative reading of the text (White and Marsh, 2006, Flick, 2014). The codebook for this study contained 5 adaptive coping strategies, 6 maladaptive coping strategies, 3 "in-between" coping strategies that could be either adaptive or maladaptive depending on the context, and one category for no coping strategy (**Table 7**). Each coping strategy was treated as its own theme.

The initial codebook (**Table 7**) was created by first author (M.C.M), by using coping definitions from Henry et al. (2019) and adapting definitions offered by Skinner et al. (2003). Coding units within the document were GTA participant coping for each anxiety card chosen for teaching or research. The first author and three undergraduate research assistants (co-authors A.C., O.F., and K.P.) used the codebook to iteratively analyze the Biology GTA interviews transcripts from 2016 and 2017 (Glaser & Strauss, 1967; Schwandt, 2007). In each round of analysis, researchers independently coded six randomly selected interview transcripts. Researchers could assign as many codes as existed for each participant response, thereby possibly having multiple codes per unit.

Inter-rater reliability was calculated after each round of analysis. Inter-rater reliability is a measure of agreement among raters; Greater consensus among raters indicates higher reliability in the themes found (LeBreton & Senter, 2008; McHugh, 2012). If coding agreement was lower than 80%, coders would re-examine their understanding of the codebook definitions and re-code a new set of randomly selected transcripts. Three iterations of this method were conducted to reach a minimum kappa 0.80 consensus (Landis and Koch, 1977). Two coders (O.F. and K.P.) then coded the remaining Fall 2016 and 2017 interview transcripts, checking in with each other and the other two coders (M.C.M. and O.C.) about any discrepancies or confusion in analysis.

To answer the first research question (how GTAs cope with teaching and research anxieties), we tallied the presence and absence of each coping strategy for each participant for teaching and research anxieties, respectively. For example, if a participant indicated they coped with anxiety about grading consistently by making a rubric, we would designate that participant as having coped through problem-solving. After tallying the emergence of each theme among GTA participants, we calculated a total percentage. For instance, if 20 participants indicated they coped with teaching anxiety through problem-solving, the percent emergence of that theme in the population would be $(20/23) \times 100 = 87\%$. Note that this means that coping was tallied as presence for an individual, not frequency of use by that individual.

To answer our second and third research questions relating to changes over time and relationships with career aspirations, we tallied the presence and absence of each coping strategy for each participant in each specific subgroup. To compare years, we calculated the percent emergence of themes among the 23 Biology GTAs from 2016

and 2017 interviews, respectively. These compiled data were then used to compare percent emergence of the same themes in 2016 versus 2017. The population was then further separated into individuals who self-reported as pursuing an academic versus non-academic career paths, and the percent emergence was compared between those groups each year. To check whether certain subgroups who traditionally experience differential anxieties cope differently (such as women and ethnic minorities; Evans et al., 2018; George, Saclarides, & Lubienski, 2018), percent emergence of themes among different genders, ethnicities, and citizenship statuses (domestic vs. international students) were compared.

We decided that we would indicate notable differences in coping strategies between groups (e.g. teaching vs. research anxieties, 2016 vs. 2017, or GTAs with academic vs. non-academic career aspirations) when there was at least a 10% percent emergence difference in strategies. For example, if 100% of participants used support seeking to manage research anxiety, and 85% for teaching anxiety, we would indicate a notable difference between how the GTAs in this population coped between teaching and research. Percent emergence or change less than 10% would just be reported. Pseudonyms, aligned with participant's gender and ethnicity, have been used throughout the results.

Table 7. Codebook theme definitions based on coping strategies outlined from Skinner et al. (2003) and Henry et al. (2019).

Coping themes	Type of coping strategy	Adapted definitions from Skinner et al. (2003)	Definitions from Henry et al. (2019)	Illustrative Quote(s) in Teaching	Illustrative Quote(s) in Research
1) Problem Solving	*Adaptive coping*	Problem-focused categories of instrumental action, strategizing, and problem solving. Planning, logical analysis, effort, persistence, and determination to solve the stressor. Watch and learn; mastery; efficacy.	Attempting to solve the stressor at hand, such as planning a potential solution and enacting that solution.	"*I try to plan and carve out time to prep for teaching. If I know it's going to take me 3 hours to prep my lesson, I carve out a block of 3 hours where I can work on that."* – Hannah 2017	*"I read over experiments several times, then I try to ask questions and figure out how to conduct that lab work and see how much time it's going to take to be able to do it."* – Hannah 2017
2) Support Seeking	*Adaptive coping*	Seeking support included a wide array of targets for support (e.g., parents, spouses, peers, professionals, and God) and a variety of goals in going to people (e.g., instrumental help, advice, comfort, and	Use of available social resources for help with the stressor or to receive emotional comfort.	"*But if I feel very unhappy, I definitely will talk with someone and see how to deal with it.*" – Sunny 2016	*"I've talked to my peers about it. [Particularly] other women in the sciences and they say they struggled the exact same stressor."* – Emily 2016

Table 7 Continued

		contact). Using others for emotional support. Proximity-seeking, yearning			
3) Information Seeking	*Adaptive coping*	Attempts to learn more about a stressful situation or condition, including its course, causes, consequences, and meanings as well as strategies for intervention and remediation. Individual reads, observes, prepares, asks others for help as they act (use external sources).	Attempting to learn more about a stressful situation or condition in order to understand the cause, consequences, or potential solutions to a problem.	"*I try to bring my student's questions with me to my TA meetings so I can get answers from people who know better and report back to them."* – Jack 2017	*"I dig through the literature and try to make inferences on what I think is important."* – Samantha 2016
4) Self-reliance or emotional regulation	*Adaptive coping*	Emotion regulation attempts to influence emotional distress and to constructively express emotions at the appropriate time and place.	Attempting to influence one's own emotional distress (to alleviate or mollify emotional distress) and to	*"Sometimes I get really frustrated on the inside, so I try to take some deep breaths."* – Lauren 2017	*I just try to tell myself "It's okay, you don't have to know everything."* – Raegan 2016

Table 7 Continued

		Self-encouragement and comforting, emotional control, relaxation, emotional expression, self-soothing, internal talking to control your emotions, pep talking.	constructively express emotions at the appropriate time and place.		
5) Cognitive restructuring	*Adaptive coping*	Explicit positive recognition of a stressor. Individual actively attempts to change one's view of a stressful situation in order to see it in a more positive light. Focus on the positive, positive thinking, optimism, and minimization of distress or negative con- sequences.	Attempting to change one's view of a stressor in order to see it in a more positive light.	"*As in like the anxiety you feel to this- the way to cope is by* '*I'm just going to read it and I'm going to take it as good criticism or criticism to improve'"* – Raegan 2016	*"If critique impacts me in a positive way then I see benefit from it and then I work on it."* – Hannah 2016
6) Accommodation	*Either Adaptive or Mal*	Individual actively attempts to adjust to constraints, minimize the stress,	Accepting the stressor and no longer trying to directly act to	"*Shut up and grade? Like you just do it and have no choice. It has to get done*	*"I think that the best way for me to cope with it is to find that*

Table 7 Continued

	adaptive coping	seems to be focused on the self. Acceptance, also can focus on the positive or distract, and attention redeployment.	solve the stressor. Does not preclude acting to circumvent or navigate the stressor.	*and the students need it."* – Madison 2017	*peak productivity time and just go with it."* – Hannah 2016
7) Negotiation	*Either Adaptive or Mal-adaptive coping*	Individual actively attempts to work out a compromise between the priorities of the individual and the constraints of the situation. Priority setting, proposing a compromise, persuasion, reducing demands, trade-offs, and deal making.	Proposing a compromise or making a deal with others to alleviate or solve the stressor Individual bargaining with others/options to change situation, persuasion, compromise	N/A	*"I think it may take, because, like, the topic I'm doing now I first brought up the beginning of this year he's not interested. Then, I brought up again this summer, still not interested, but I still keep doing. Then, he was kind of convinced. 'Okay, you can do this.'"* – Sunny 2017
8) Escape	*Mal-adaptive coping*	Individual makes efforts to disengage or stay away from the stressful transaction.	Avoidance of the problematic environment and/or stressor, including denial	"*I do my absolute best to just block it out when I'm teaching, which I can do."* – William 2017	*"When I really don't want to deal with it, I ignore it. Just let it sit in my inbox and slowly get pushed under*

Table 7 Continued

		Cognitive avoidance, avoidant actions, denial, and wishful thinking.	of the stressor.		*these new things and get reminded later."* – Laretta 2017
9) Distraction	*Either Adaptive or Mal-adaptive coping*	Individual actively attempts to deal with a stressful situation by engaging in an alternative pleasurable activity. Alternative activities, such as hobbies, exercise, watching TV, seeing friends, or reading.	Engaging in an alternative pleasurable activity in an attempt to alleviate emotional distress associated with a stressor.	"*I'd say I actually look at teaching or prepping to teach as kind of an escape from the anxiety of research (M Affirms), so the time away from my research while I'm in that time away from it I actually enjoy it."* – William 2017	*"I impulse buy online to cope with my stress."* – Laretta 2017
10) Isolation	*Mal-adaptive coping*	Individuals withdraw from interaction, hides, avoids others to hide the anxiety; particularly with individuals they have social capital with (friends, family, etc.). Actions are aimed at staying away from other people or preventing other people from knowing about	Avoiding other people to hide stressor or preventing other people from knowing about a stressor or its effects.	N/A	N/A

Table 7 Continued

		stressful situation or its emotional effects. Social isolation, avoiding others, concealment, stoicism, and emotional withdrawal.			
11) Rumination	*Mal-adaptive coping*	Individual concentrates on the negative features of a situation). Passive and repetitive focus on the negative and damaging features of a stressful transaction Intrusive thoughts, negative thinking, catastrophizing, anxiety amplification, self-blame, fear, and submission.	Repeatedly thinking negatively about a stressor and about one's own role in that transaction. Associated with catastrophizing and self-blame.	"*Yeah and it stays with you forever. Just stays in your head and you can't get over it.*" – Hannah 2017	*"I feel like I do the opposite of coping with it because I think about it too much."* – Sarah 2017
12) Helplessness	*Mal-adaptive coping*	Actions organized around giving up or the relinquishment of control. Lack of control in a situation,	Acting to give up or relinquish control of a situation. Individuals seem	Interviewer: "*And what do you do to cope?"* Katilyn: "*Um, I don't.* Interviewer: "*Nope."*	*"I'll worry but it's not going to change anything."* – Raegan 2016

Table 7 Continued

		giving up. Individual's response during interview often does not answer anything about coping. Passivity, confusion, cognitive interference or exhaustion, dejection, and pessimism.	to indicate an inability or lack of knowledge of how to cope.	Kaitlyn: "*Nothing*." – Kaitlyn 2017	
13) Delegation	*Mal-adaptive coping*	A negative social interaction; individual complains, whines, expresses self-pity, dependency, or maladaptive help seeking.	Shifting the problem to someone else through maladaptive help-seeking such as whining and self-pity.	N/A	N/A
14) Opposition	*Mal-adaptive coping*	The individual expresses aggression, anger, blaming, defiance with situation or issue	Externalizing one's negative emotions as behaviors directed at others in connection with the stressor.	"*Sometimes I just tell my students to shut up and it makes me feel like I have authority."* – Jack 2017	N/A

Table 7 Continued

		Projection, reactance, anger, aggression, discharge, venting, and blaming of others.			
15) No Coping	N/A	Individual did not identify any coping strategies to mitigate anxiety, or that individual expressed feeling little anxiety about a topic and did not need to cope. They do not think about coping or feel the need to cope.	N/A	"*I don't really [cope]. I don't know."* – Laretta 2017	*"I don't know if I do cope with it."* – Lucy 2017

Results

RQ 1a: Adaptive coping themes were more prevalent than maladaptive themes among GTAs

Graduate students primarily employed adaptive coping strategies to manage anxieties in teaching and research. These strategies include problem solving, information seeking, support seeking, self-reliance, and cognitive restructuring. Problem solving and information seeking were the most prominent coping themes used among GTAs for teaching and research anxieties (**Figure 11**).

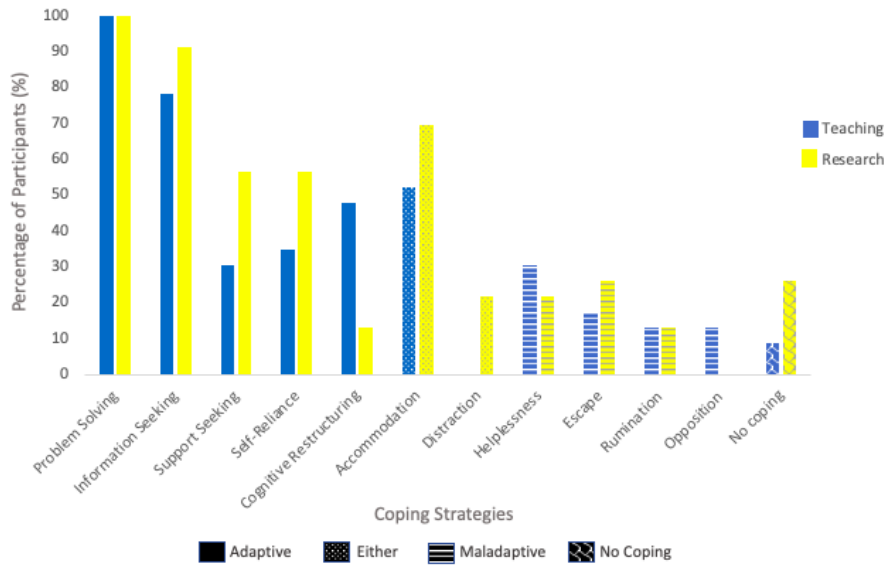
In Fall 2016, **problem solving** was used by 100% of GTA participants (n=23) for coping with both teaching and research anxieties (**Figure 11a**). Problem solving coping by GTAs was characterized often by practicing or preparing in advance for given tasks. For example, Sarah, a first year GTA, spoke about practicing her research presentations:

> "*When I gave my talk, I made the time to practice a lot of it and read a couple of key papers." - Sarah (Fall 2017)*

In Fall 2017, 100% of the GTA participants used problem solving for teaching, and only 78% used it for research (**Figure 11b**).

Support seeking coping strategies were utilized by 30% of the participants for teaching anxieties and 57% for research anxieties in Fall 2016 (n=23) (**Figure 11a**). The use of support seeking dramatically decreased in Fall 2017 for teaching and research anxieties at 9% and 39% of participants, respectively (**Figure 11b**). This theme was

A)



B)

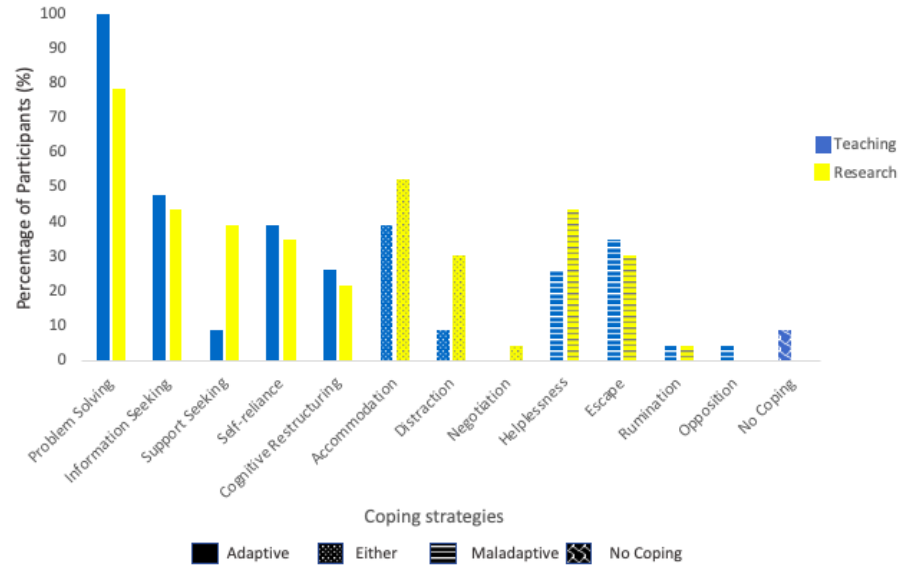


Figure 11. Coping strategies which emerged among 23 Biology GTA participants in response to teaching and research anxieties in **A**) 2016 and **B**) 2017.

often characterized by participants reaching out to their social networks for moral support (not including seeking information from others). In the interview with Emily, a 4th year doctoral candidate, she spoke about how she looked to her female colleagues when stressed about issues of women in STEM the field:

"I've talked to my peers about it. Other women in the sciences, and they say they struggled with the same exact same stressor." - Emily (Fall 2016)

In Fall 2016, 78% of participants (n=23) used **information seeking** to manage teaching anxieties and 91% for research anxieties **(Figure 11a**). The use of this coping mechanism decreased to 47% of participants for teaching anxieties and 43% for research anxieties in Fall 2017 (**Figure 11b**). One of our GTA participants, Lauren, indicated that to manage her anxiety over living off her limited teaching stipend, she sought more information about better money management skills:

"I'm reading a finance help book right now. My parents are also really good with money and I talk with them a little bit." - Lauren (Fall 2017)

Around 35% and 57% of participants coped with their teaching and research anxieties, respectively, by using **self-reliance**. In 2017, this stayed relatively the same at 39% of the participants for teaching anxieties and dropped to 35% of the participants for research anxieties (**Figure 11b**). Lauren explained how she dealt with being unable to answer student questions right away by using self-reliance:

"After the class is over, I try to reassure myself and figure out things I can do with the next class." - Lauren (Fall 2017)

In Fall 2016, **cognitive restructuring** was utilized by 48% of participants for teaching anxieties and 13% for research anxieties (**Figure 11a**), but in Fall 2017 had decreased to 26% of the participants for teaching anxieties and increased to 22% of the participants for research anxieties (**Figure 11b**). For example, Reagan used cognitive restructuring to positively receive feedback from teaching evaluations and make improvements for the future:

"*[I] just try to do a good job and if there is constructive feedback or something, I use it." - Raegan (Fall 2017)*

However, use of in-between and maladaptive coping strategies still emerged in Biology GTAs

Of the maladaptive and in-between coping strategies, GTAs often employed escape, distraction, and helplessness.

Among in-between coping strategies, participants did not use **distraction** to cope with their teaching anxieties in 2016, however, 26% of the GTA participants employed it when managing research anxiety (**Figure 11a**). Recall that "in-between" coping strategies could be adaptive or maladaptive depending on the context that the coping mechanism was used. If distractions were only temporary, they would be considered

more adaptive than maladaptive. The use of distraction slightly increased in 2017 with 9% and 30% of the participants using it for teaching and research anxiety, respectively (**Figure 11b**). Emily explains how she coped by using distraction as an adaptive coping strategy:

"I'll listen to music/tv on in the background so if I feel like I'm getting overwhelmed or frustrated writing the same thing over and over again; I can take a break and come back."

- Emily (Fall 2017)

In our GTA participants for Fall 2016, 52% and 70%, respectively, used **accommodation** to cope with their teaching and research anxieties. The use of accommodation decreased in 2017 to 39% of participants for teaching anxieties and 52% for research anxieties (**Figure 11b**). For example, Laretta explained how she used accommodation to combat the anxieties that emerged when teaching students certain topics:

"*I don't extensively study every topic so…I just roll with it as it comes- do what I have to at the moment to help that specific student." - Laretta (Fall 2017)*

The last in-between coping strategy which emerged was **negotiation**. Negotiation was only found in 4% of GTA participants when talking about coping with research anxieties in Fall 2017 (**Figure 11b**). The theme did not emerge for teaching

anxiety in either 2016 or 2017 or in dealing with research anxieties in 2016. One of our international student participants, Sunny, used negotiation as a coping strategy when discussing with her advisor new ideas for her research:

"I think it may take [persistence], because, the topic I'm doing now I first brought up the beginning of this year [and my advisor was] not interested. Then, I brought up again this summer--[and he's] still not interested, but I still keep doing it. Then [eventually], he was kind of convinced, "Okay, you can do this."" - Sunny (Fall 2017)

Escape was used in 16% and 26% of the GTA participants, respectively, when dealing with teaching and research anxieties in 2016 (**Figure 11a**). These percentages increased to 35% and 31% of the participants for teaching and research anxieties, respectively, in 2017 (**Figure 11b**). Escape is when an individual executes avoidance or long-term disengagement from the stressor, which is distinct from the coping strategy of distraction. For example, Lucy, a domestic first year Ph.D. student, explained that she avoided feedback from her advisor when she became stressed:

"I try to ignore those comments." - Lucy (Fall 2017)

In 2016, 13% of the GTA participants (n=23) used **rumination** to cope with both their teaching and research anxieties in 2016 (**Figure 11a**). In 2017, there was a decrease to 4% of participants for both teaching and research anxieties (**Figure 11b**). For example, when an upcoming research deadline is pending, Arnold used rumination

by constantly thinking about the task until it was due:

"I just obsess over it until my time runs out…" - Arnold (Fall 2016)

Helplessness, a coping strategy characterized by actions organized around giving up or the relinquishment of control, was the most commonly used maladaptive coping strategy in the 2016 and 2017 interviews. Thirty percent of the GTA participants expressed helplessness as a coping strategy in teaching and 22% in research in 2016 (**Figure 11a**). In 2017, 26% of participants used helplessness in teaching and 43% of participants in research (**Figure 11b**). Reagan, a first year GTA, explained that she struggled with managing her finances in graduate school:

"I'll worry but it's not going to change anything." - Reagan (Fall 2016)

Among our GTAs, participants used **opposition** as a coping strategy only for teaching anxieties. In 2016, 13% of participants used this coping strategy and 4% in 2017 (**Figure 11**). The theme did not emerge in GTA interviews when discussing how they coped with research anxieties. Rebecca explained how she coped with dealing with difficult feedback (from her advisor):

"Well, when I got the email of her feedback after she observed me teaching a lab, of course I was frustrated, because I felt that it was unfair she had focused on very minor

details of the lecture (walking around the classroom) instead of more overarching ideas."

- Rebecca (Fall 2016)

The last two maladaptive coping strategies, **isolation** and **delegation**, were not expressed by our participants in Fall 2016 and 2017 and thus were not included in Figures.

Lastly, when GTA participants did not express any coping strategies to mitigate anxiety or feel as if they did not need to cope, we coded those instances under a **No Coping** theme. This theme was used in 9% and 26% of the participants, respectively, in dealing with teaching and research anxieties in 2016 (**Figure 11a**). In 2017, the theme was used in 9% of the participants again in teaching, and none in dealing with research anxieties (**Figure 11b**). For example, Lucy expressed that she may not be able to cope with time management skills in preparing for a class:

"I don't know [if I cope]. Nothing?" - Lucy 2017

RQ 1b: GTAs tended to use a wider breadth of coping strategies to manage research anxieties compared to teaching anxieties

Generally, Biology GTAs used similar adaptive and maladaptive coping strategies to manage their teaching and research anxieties, particularly expressing ideas related to problem solving, information seeking, accommodation, escape, and helplessness. However, there were a few notable differences in coping with teaching or

research anxiety. GTAs tended to use more support seeking, self-reliance, accommodation, and distraction when managing research anxieties. Conversely, GTAs tended to use more cognitive restructuring to deal with teaching anxieties. A greater diversity of coping strategies emerged in participants for research anxieties compared to teaching anxieties in Fall 2016, with 6 coping strategies (information seeking, support seeking, self-reliance, accommodation, distraction, and escape) emerging in research contexts (**Figure 11a**). Only 3 coping strategies (cognitive restructuring, helplessness, and opposition) emerged more often in teaching contexts than research in Fall 2016 among Biology GTA participants. However, in Fall 2017, GTA coping between teaching and research anxieties became more similar (**Figure 11b**). No differential trends were identified among subgroups (e.g. gender, ethnicity, citizenship), see **Appendix Figures 7-9.**

RQ 2: Over time, use of adaptive coping strategies decreased in Biology GTAs

From 2016 to 2017, Biology GTA participants decreased their use of adaptive coping strategies (**Figure 12**). Though this decline was observed among participants for some maladaptive coping strategies as well, these changes pronounceably changed over time for adaptive coping strategies when managing teaching and research anxieties. For example, strategies such as information seeking, support seeking, and accommodation declined in both teaching and research.

In teaching, the most dramatic decreases were with the use of adaptive coping mechanisms such as information seeking (-30%), support seeking (-22%), and cognitive restructuring (-22%; **Figure 12a**). The use of information seeking had the most notable

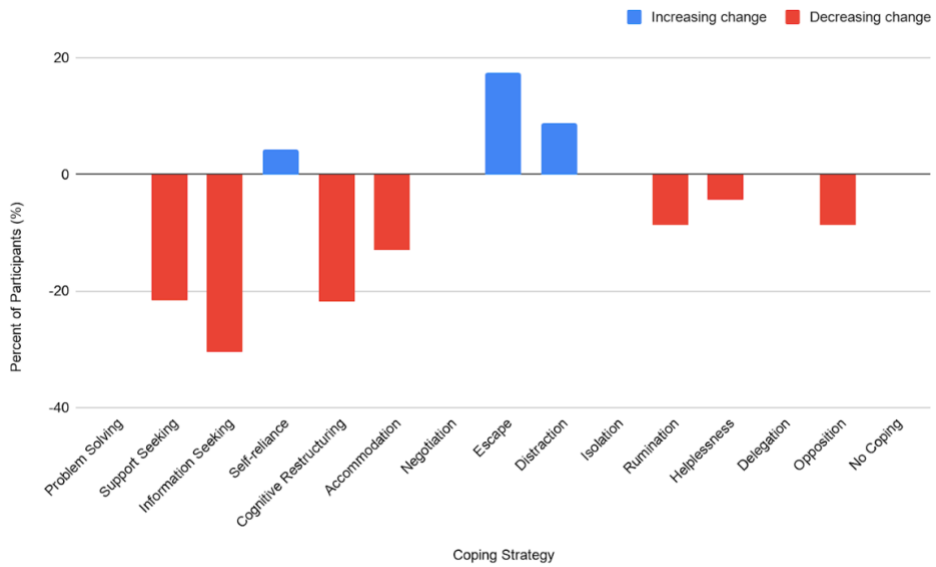
decrease within the sample population from 2016 to 2017. Use of maladaptive coping mechanisms such as rumination (-9%), helplessness (-4%), and opposition (-9%), had minimal decreases between 2016 to 2017, though they were comparatively used less than adaptive strategies generally. The use of escape (+17%), distraction (+9%), and self-reliance (+4%) to cope with teaching were the only strategies to increase over time. Problem solving and no coping remained constant between 2016 and 2017.

We found similar trends in coping with research anxiety over time (**Figure 12b**). There tended to be a decrease in the use of adaptive coping, such as problem solving (-22%), support seeking (-17%), information seeking (-48%), and self-reliance (-22%) from 2016 to 2017. No coping (-22%) also notably decreased. While, information seeking had the greatest decrease in prevalence among participants over time, GTAs slightly increased their use of cognitive restructuring (+9%), though not notably. Conversely, we found that there was a slight increase in the use of in-between or maladaptive coping mechanisms such as negotiation (+4%), escape (+4%), distraction (+9%), and helplessness (+22%). Helplessness had the largest increase from 2016 to 2017.

RQ 3: Biology GTAs with academic career aspirations have less fluctuations in coping over a year compared to GTAs with non-academic career aspirations

Comparing GTAs with academic (n=11) and non-academic career aspirations (n=12), across context and years, both groups relied heavily on adaptive coping strategies, especially problem solving and information seeking (**Figure 13**). Accommodation, escape, and helplessness were shared in-between or maladaptive coping strategies between groups. Interestingly, GTAs with non-academic career goals

A) Teaching anxieties



B) Research anxieties

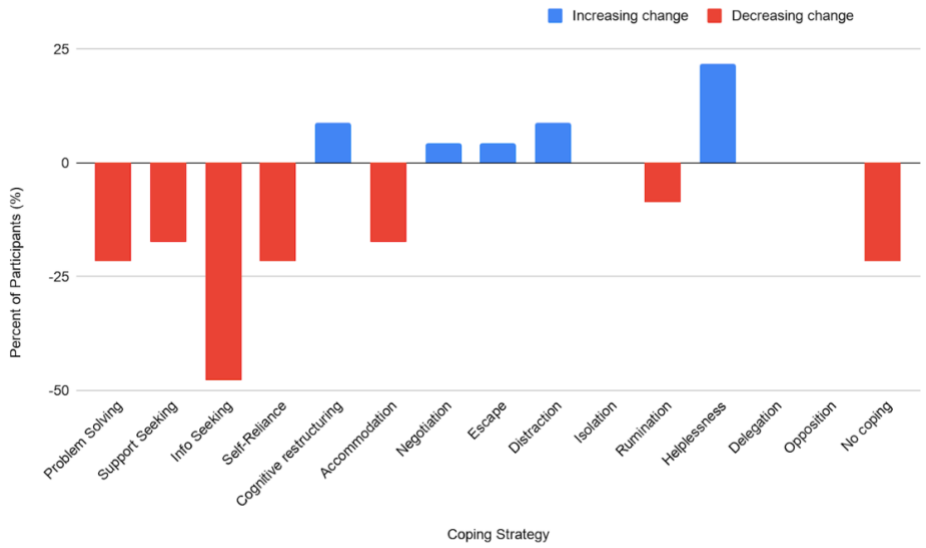
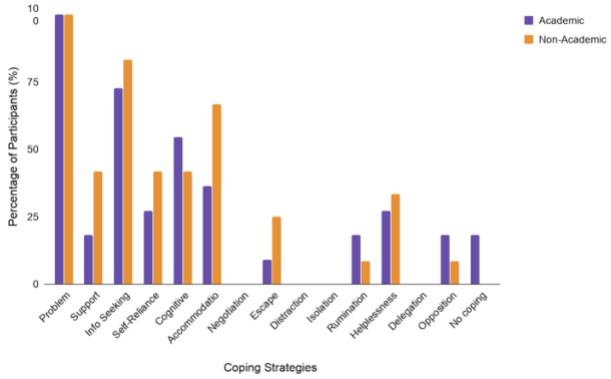


Figure 12. Change in coping strategies from 2016 and 2017 among 23 Biology GTA participants for **A**) teaching anxieties and **B**) research anxieties. Blue bars indicate an increase in the use of that coping strategy from 2016 to 2017, while red bars indicate a decrease in that coping strategy use by participants from 2016 to 2017.

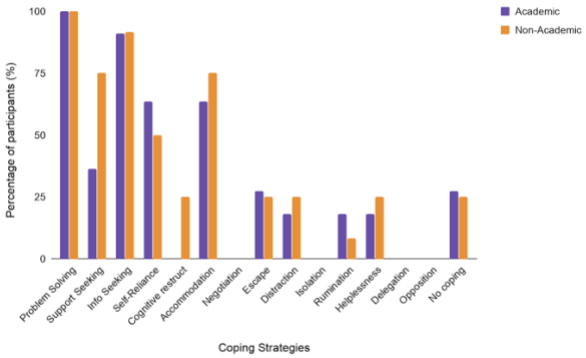
often used support seeking as their coping strategy for teaching (40%) and research anxieties (75%) in Fall 2016 compared to GTAs with academic career goals (17% and 40% respectively; **Figure 13a, b**), though this trend declined in 2017.

Over time, we found that GTAs with academic career aspirations fluctuated less in their coping strategies for research anxieties, compared to GTAs with non-academic career aspirations (**Figure 14**). GTAs with academic career goals had coping changes in 8 strategies, while GTA with non-academic career goals had coping changes in 10 strategies. Generally, both groups declined in use of coping toward research anxieties. However, those who indicated future pursuits of non-academic career paths had more declines in the use of adaptive coping strategies over time (e.g. problem solving, self-reliance) and increases in in-between/maladaptive coping (e.g. distraction, escape, negotiation) in dealing with research anxieties compared to participants who aspired toward academic careers. Towards teaching anxieties, GTAs with academic career aspirations had more declines in coping towards teaching anxieties than non-academic GTAs, except for information seeking. Participants aspiring toward academic careers appeared to have less change in coping over a year, except for information seeking.

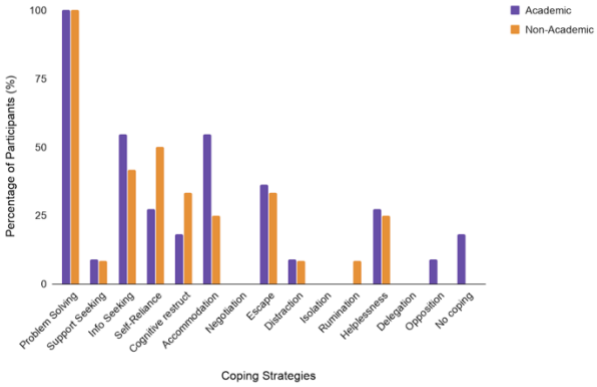
A) Teaching 2016



B) Research 2016



C) Teaching 2017



D) Research 2017

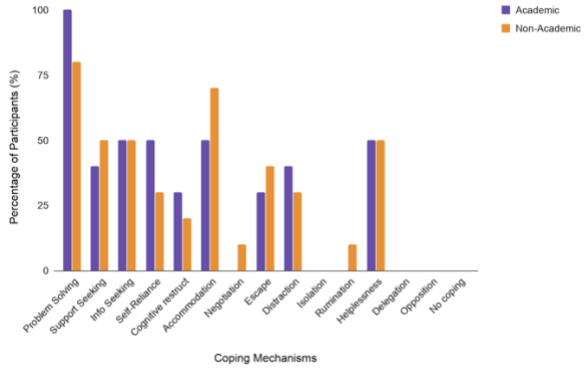


Figure 13. The percentage of participants (n=23) who exhibited each coping strategy, between GTAs with academic (purple, n=11) vs. non-academic (orange, n=12) career aspirations, for **A**) teaching anxiety in Fall 2016, **B**) research anxiety in Fall 2016, **C**) teaching anxiety in Fall 2017, and **D**) research anxiety in Fall 2017.

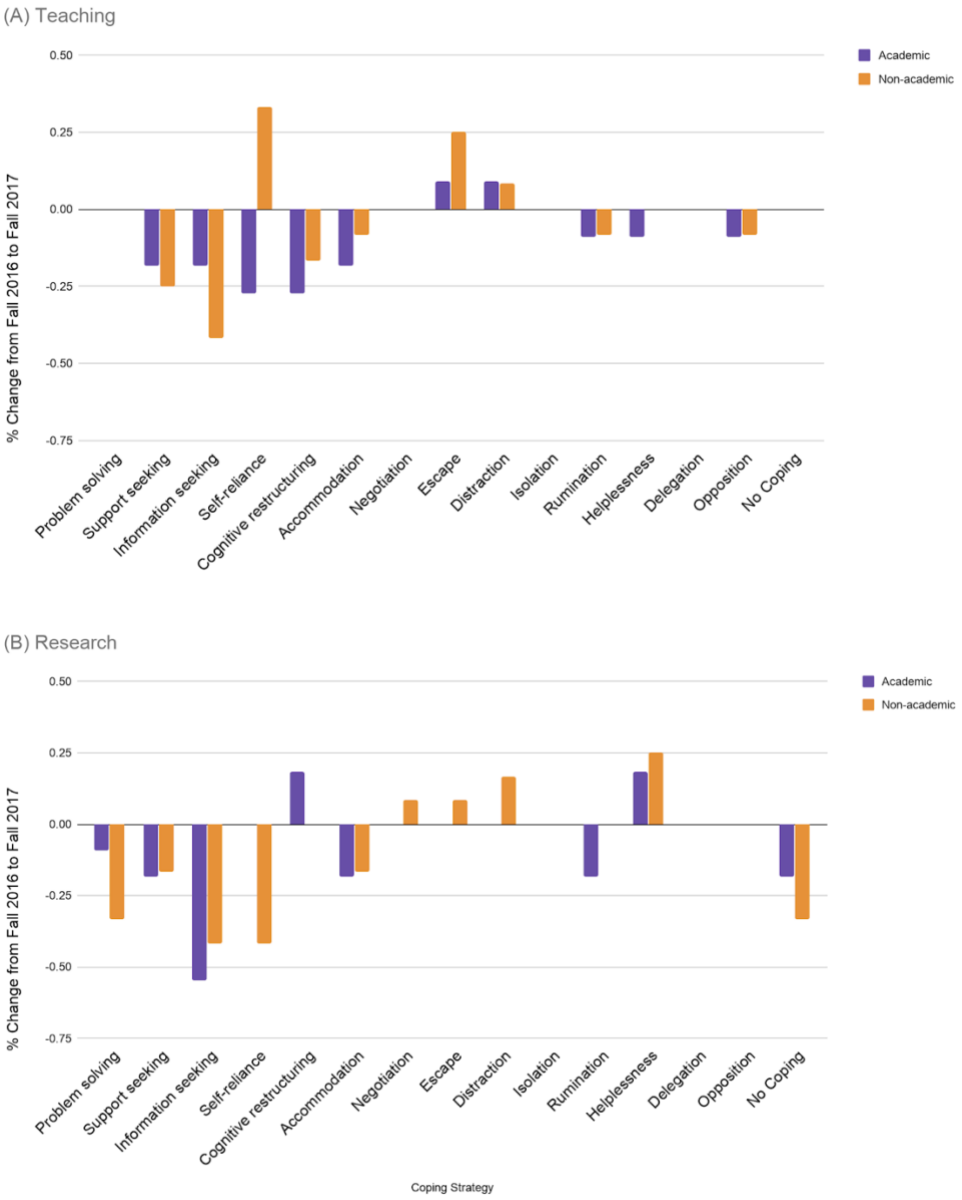


Figure 14. Coping strategies between GTAs with academic vs. non-academic careers from 2016-2017. Graphs display how **A**) coping with teaching anxiety and **B**) coping with research anxiety changed among GTAs with academic aspirations over one year; and how **C**) coping with teaching anxiety and **D**) coping with research anxiety changed among GTAs with non-academic aspirations over one year.

Discussion

Overall, Biology GTAs demonstrated a greater use of adaptive coping strategies in managing both teaching and research anxieties, compared to maladaptive coping strategies. However, GTAs tended to use a wider breadth of coping strategies to manage research anxieties compared to teaching anxieties. Over time, use of adaptive coping strategies decreased for both teaching and research anxieties, however, this was not associated with any increases in the use of maladaptive strategies. These decreases in adaptive strategies were more likely to be seen in GTAs who reported non-academic career aspirations. Those aspiring to academic positions tended to have more stable coping strategies over time. These results provide preliminary support for adding the components of anxiety and coping to the SCCT model because GTAs with different career prospects do seem to differ in some aspects of anxiety (Chen Musgrove et al., in review) and coping to their teaching and research roles. This is important for institutions and departments to consider because supporting mental health of graduate students may need to consider not only differences in support for teaching and research roles, but also in support for those students considering different career pathways.

Biology GTAs primarily employed adaptive coping strategies to manage both teaching and research anxieties

Our results revealed that Biology GTAs primarily used adaptive coping strategies to manage their anxieties in both teaching and research contexts. Among such strategies, participants prominently utilized problem solving and information seeking. Previous studies investigating graduate students also found similar adaptive coping

trends in graduate students (Chang & Edwards, 2015; El-Ghoroury et al., 2012; Kjerulff & Wiggins, 1976; Nelson et al., 2001). Adaptive coping strategies may be more often used among GTAs because they have practiced using such strategies in managing anxieties during their undergraduate careers. Graduate students are a highly selective group and often did well in their undergraduate education. Studies on coping and academic success in college students have found that students who employed adaptive, problem-focused coping often had a higher grade point average (Johnson and Michael Nussbaum 2012; MacCann et al. 2011). This suggests graduate students may enter their programs with adaptive coping strategies already in place. Students entering graduate school also often have been previously involved in undergraduate research experiences (Harsh, Maltese, and Tai 2011), allowing for further development of coping skills related to research.

Despite similarities in coping strategies between teaching and research, there were notable differences in which particular coping strategies were more prevalent in one context versus the other. In teaching contexts, GTAs tended to use problem solving, information seeking, and cognitive restructuring. Both problem solving and information seeking involve GTAs actively either searching for information or coming up with solutions to challenge they are experiencing. This may be particularly important given the traditional lack of teaching professional development and support that GTAs are provided prior to and even during their teaching roles (Schussler et al. 2015). Individuals who employ cognitive restructuring try to take a stressor that is causing them unpleasantness and see it in a positive light. Besides concerns about the time teaching takes away from research, GTAs also lament the lack of autonomy in the classroom

which can cause anxiety (Kajfez and Matusovich 2017a; Winstone and Moore 2017). Their positions often function to implement a pre-determined curriculum that may not be flexible to GTA input. Cognitive restructuring may help GTAs to re-frame their teaching experiences to see the benefits of the tasks, despite their lack of autonomy.

In research contexts, Biology GTAs tended to use more support seeking, self-reliance, and accommodation to manage their anxieties, and generally used a variety of coping strategies more often than they did for their teaching role. In light of the sometimes great isolation that comes with being in graduate school (T. M. Evans et al. 2018), the use of strategies like support seeking is unsurprising. Support seeking is critical for the socialization process of graduate students, often involving peers or friends, but especially their advisors. Positive and close relationships between graduate students and their advisors often predict successful student outcomes, such as shorter time to degree, greater job satisfaction, and well-being (Bagaka's et al. 2015; Ferrer De Valero 2001; German, Sweeny, and Robbins 2019; O'Meara et al. 2014; Sverdlik et al. 2018). Self-reliance and accommodation can be considered more cognitive- and emotion-focused coping strategies, which are employed when lack of control over situations or research tasks arise (Chen et al., In prep). The greater variety of coping strategies used for research versus teaching could potentially be due to research feeling more open-ended and unknown in outcome compared to teaching. It may also be that socialization to value research over teaching causes more behavioral resources to be utilized for this role as a graduate student (Austin 2002).

Biology GTAs also employed some maladaptive coping strategies

In both teaching and research roles, maladaptive and in-between coping strategies were used by GTAs as well. For teaching anxieties, GTA participants used helplessness, accommodation, and escape. These feelings of helplessness and cognitive acceptance (accommodation) of a teaching situation may be attributed to a combination of role tension (between teaching and other responsibilities), a lack of self-efficacy in teaching, especially for first year GTAs (Chen Musgrove et al., in review), and the aforementioned lack of autonomy in teaching. These suggest a feeling of being trapped and lacking support, once again suggesting the need for ongoing teaching professional development to help GTAs manage this important institutional role (Prieto and Scheel 2008; Rushin et al. 1997). Similarly, to manage research anxieties, GTAs employed coping strategies such as accommodation, distraction, escape, and helplessness. Anxieties rooted in role tension between teaching, research, and other priorities can grow with greater demands from those priorities over time (Austin 2003; Park 2002; Winstone and Moore 2017). Research progress is a major part of the evaluation of progress by their programs; research is often difficult and not linear, and this lack of control may lead to negative coping behaviors.

Although teaching and research coping was measured separately, there is an interplay between the two which cannot be ignored in a graduate program. Time spent on teaching is time not spent on research, and many graduate students feel the pressures of these time constraints themselves, or sometimes even imposed by their advisors. These pressures also mount over time as career choices loom and excelling at research, teaching, and service seem to matter even more. There is also little stability

for some students, with changes in teaching roles over time requiring the preparation of new material. This can be said also with novel research-related tasks (e.g. trying to learn a new statistical analysis on a time crunch). The extent to which anxieties and coping are related to the combination of teaching and research roles is an area that needs to be further explored.

Over time, Biology GTAs may be finding more stable forms of coping

Over one year, GTAs decreased their use of adaptive and some maladaptive coping strategies in managing teaching and research anxieties. It is possible that these GTAs may be using fewer adaptive coping strategies to manage their anxieties after one year because they have identified the most effective coping approaches, and thus stabilizing their coping. Lazarus (1993) and Spencer et al. (1997) maintain that coping strategies often become increasingly stable over time, with individuals utilizing only a few primary coping approaches in specific contexts. Graduate students, particularly those in their first year, may be trying to reconcile their previous coping approaches from past undergraduate experiences to determine the best adaptive or maladaptive coping strategies toward graduate school tasks. For example, a GTA embarking on a new statistical analysis may use several coping strategies as they manage new anxieties. If they find that information seeking works the most efficiently and effectively, they may just remain with one strategy in the future.

According to the SCCT model, stabilizing coping strategies over time may be attributed by improving task self-efficacy and having positive outcome expectations. When Chang and Edwards (2015) surveyed 314 nurses about self-efficacy, coping, and

job satisfaction, they found that self-efficacy was positively associated with problem-focused coping styles, and greater job satisfaction and negatively associated with emotion-focused, maladaptive coping (Chang and Edwards 2015). The influence of self-efficacy on job satisfaction was indirect and partially mediated by coping styles. Over time, as an individual socializes into their program and may be exposed to some similar work tasks, mastery experiences will help them grow in self-efficacy and coping. However, the onset of new tasks (e.g. writing for publication, more data collection) may make it difficult to figure out how to cope initially, initiating coping responses that may not be adaptive.

When comparing teaching and research contexts, coping strategies to manage research anxiety had less fluctuations over time relative to teaching, suggesting GTAs are maximizing coping to research more quickly than teaching (Lazarus, 1993; Spencer et al., 1997). This may be because many have experience with undergraduate research but perhaps not experience with teaching as an undergraduate. However, the maladaptive coping strategy of helplessness notably increased over the year for research. Graduate students are expected to master a myriad of skills in order to be successful in their respective programs, particularly early in their programs. A study following undergraduate medical students found that when students experienced the most stress in academia, they were the most likely to employ coping strategies such as rumination and escape, disengaging with the stressor entirely (Cherkil, Gardens, and Soman 2013). This suggests that when under a great deal of stress, particularly related to tasks where individuals have low self-efficacy for and negative outcome expectations initially, students may be drawn to maladaptive approaches. It is possible that the

Biology GTAs in this study similarly disengaged sometimes depending on how overwhelming their new stressors were.

Biology GTAs with academic career aspirations have less changes in their coping over time towards research anxieties

We posited that the more aligned a GTA's career goals are with the tasks they are most engaged in (e.g. teaching and/or research), the more adaptive coping they would have for any anxieties related to those tasks. The SCCT model we proposed suggests that coping can influence an individual's career interests and goals through managing anxiety and impacting self-efficacy and outcome expectations. Successfully coping with an anxiety related to such tasks would then further progress and support one towards said career goal. From our data, Biology GTAs with academic career aspirations appeared to be stabilizing their coping skills towards research tasks, compared to GTAs with non-academic career aspirations.

Our study provides preliminary qualitative support to suggest that a GTA's coping strategies are related to their career aspirations. Career aspirations are continually shaped during the socialization of graduate students in their program. During this time, struggle is often normalized (Posselt 2018). Normalized struggle supports persistence and perseverance, but only with the proper supports in place for adaptive coping to also develop. We found decreases in the use of adaptive coping strategies over time in our sample population. However, participants pursuing academic careers appeared to have less change in their coping over time with research anxieties. This may indicate that they are learning the best ways to cope, and thus stabilizing their coping approaches to

manage research stressors (Lazarus and Folkman 1984; Spencer, Dupree, and Hartmann 1997). For those looking to embark on research as a future career, we would expect a greater coping ability over time towards anxieties in research, and progressively observe less changes in their approaches. For example, support seeking did not change drastically over time in managing research anxieties. Previous studies have found that graduate students who talked to their advisor were more likely to apply to and prioritize tenure-track positions (German, Sweeny, and Robbins 2019). Therefore, GTAs with career pursuits in academia may be effectively utilizing support seeking as a means to cope with research anxieties, while developing their career interests.

Those with non-academic career aspirations, all of whom maintained these aspirations over a year, had greater changes, both increasing and decreasing, in coping strategies over time for teaching and research contexts. These fluctuations in coping strategies may reflect that these GTAs are searching for the best supports to help them progress through anxieties that may not align with their career goals. Austin (2003) found that doctoral students frequently worry whether it is possible to live a “balanced” or “integrated” life, and if it is possible to give attention to both personal and professional responsibilities (Austin 2003). Graduate students may also struggle to find adaptive coping strategies if their advisors are not supportive of their career goals. These participants may have developed their non-academic career goals before or during the socialization process within graduate school. Roach & Sauermann (2017) surveyed 854 Ph.D. students in science and engineering and found 25% of the population lost interest in an academic career during their program, while 15% came into the program were

never interested in an academic career. When GTAs observe their doctoral mentors and faculty colleagues and find that academia is not the career path they want to pursue, GTAs must consider alternatives from the skills they are gaining during the doctoral journey. Acquiring these new skills, or reframing old skills, may lead to greater changes in coping approaches over time.

Limitations

Our study identified the types of coping strategies Biology GTAs employed towards anxieties in teaching and research, however, we did not measure the efficacy of such coping. It may be that particular in-between or even maladaptive coping strategies are more effective at reducing anxieties compared to other adaptive coping strategies. For example, support seeking through positive mentoring from a doctoral advisor is often a critical component in measuring graduate student success and may be more efficacious compare to self-reliance. Future studies should consider how to best measure coping efficacy.

Another methodological limitation lies in the nature of discussing a stigmatized topic. The open-ended interview format of this study often allowed for intimacy between the participants and the interviewer. However, factors such as social desirability may have led participants to avoid talking about maladaptive coping strategies to avoid judgement. Though we ensured full confidentiality, it may be difficult to avoid the social desirability of coping adaptively.

Lastly, we recognize that coping is situational, developmental, and culturally-bound. Though our study was not able to capture variations between different

subpopulations of GTAs, we acknowledge that different subpopulations of graduate students may cope in unique ways to the same stressor. For example, cultural backgrounds often influence how students cope. When studying international student stress and coping more broadly, Mallinckrodt & Leong (1992) found that international students in the United States sought more support seeking, both from family at home and in their academic community to handle anxiety and external stressors. El-Ghoroury et al. (2012) surveyed a national sample of psychology graduate students and found that racial/ethnic minority students often utilized spiritual resources, supervision, and seeking out family support to coping, compared to white students. Future research would benefit from further investigation of differences in coping between subpopulations of graduate students.

Recommendations

Recent intervention studies have been published to help improve mental health in graduate students. From implementation of an Individual Development Plan (IDP) for graduate students (Vanderford et al. 2018) to community events addressing mental health to open discussion on the topic with mental health professionals (Mousavi et al. 2018), there are tangible ways to improve graduate student program support of graduate students. In a study of 231 employed graduate students, Nicklin et al. (2018) explored personal and psychological resources which decrease perceptions of stress. They found that mindfulness, self-compassion, and resilience were negatively related to stress. The need for self-compassion, *"a reflexive process that requires recognizing moments of pain and suffering and practicing critical awareness to explore what's*

happening", is critical for a the doctoral journey (Golnaraghi 2016; Neff, Hsieh, and Dejitterat 2005). Encouraging and modelling self-compassion and hopefulness can be an effective form of coping for graduate students (Alexander and Onwuegbuzie 2007; Golnaraghi 2016; Neff, Hsieh, and Dejitterat 2005; Neff and Vonk 2009). Future research may be directed to interventions of mindfulness training as seen for undergraduate students to combat test anxiety (H. Cho et al. 2016; D. W. Nelson and Knight 2010), further exploration of the efficacy of certain coping strategies, and how they develop over time for teaching and research contexts.

Future studies examining coping would also benefit from both a qualitative and quantitative component. Researchers have used coping instruments, such as the BRIEF COPE inventory, to quantify and measure how an individual copes with a stressor, in both adaptive and maladaptive categories (Carver, Scheier, and Weintraub 1989). Self-distraction, active coping, denial, substance use, use of emotional support, use of instrumental support, behavioral disengagement, venting, positive reframing, planning, humor, acceptance, religion, and self-blame are the coping mechanisms within the inventory. By utilizing a mixed methods approach, a greater sample size may be solicited via surveys and more specific examples of coping strategies may emerge for particular subpopulations in graduate students.

Conclusions

Graduate school is a time where students learn to balance multiple roles, such as teaching and research, and anxieties often emerge as part of this process. Learning the appropriate coping strategies to address these anxieties for each role is important to

maintain positive mental health. This study sought to capture the major coping strategies used to mitigate teaching and research anxieties, and identified that most coping strategies used by GTAs were adaptive in nature. It also suggested that coping for teaching and research anxieties differs and may even differ depending on the career trajectory of a graduate student. Graduate programs must try to encourage more effective coping strategies as students progress through their degree programs, by providing greater access to resources and mental health support to students and customizing these supports depending on their needs. Simply having supportive relationships, at the departmental and advisor level, can reduce doctoral emotional exhaustion and intentions to leave academia (Hunter and Devine 2016). Successful socialization and development of a professional identity cannot be accomplished in a vacuum. Isolation in graduate school has been positively correlated with depression, anxiety, and burnout in our students (T. M. Evans et al. 2018), leading to student attrition (Ali and Gregg Kohun 2006, 2007; Gregory and Lovitts 2003). Maintaining an instrumental social network helps to prevent isolation and thus reduce anxiety during the program. Learning to cope effectively with teaching and research anxieties may therefore help to reduce attrition in graduate programs and address the epidemic of mental health concerns that graduate students are currently experiencing.

CONCLUSION

The overall goal of my dissertation research was to capture a snapshot of mental health in academia by characterizing teaching and research anxieties, and coping strategies used by one population of Biology Graduate Teaching Assistants (GTAs) at one institution. This is also the first study to qualitatively characterize teaching anxiety, research anxiety, and coping among Biology GTAs over time and in relation to two different career aspirations. Given that GTAs bear significant teaching and research loads for research-intensive universities, these factors—such as anxiety, self-efficacy, and coping—may not only influence a GTA's well-being but also influence the quality of undergraduate education. My work supports that self-efficacy is a critical factor in mitigating teaching anxiety and that coping may moderate how self-efficacy impacts anxiety. It also definitively establishes that GTA teaching and research anxiety are different in terms of the factors that relate to them and how GTAs cope with them, and suggests that the relationships between teaching and research roles and academic career paths and GTA anxieties need to be studied in more detail to better understand the drivers of graduate student mental health.

Using a combination of quantitative (e.g. survey data) and qualitative (e.g. interviews) methodologies, I collected data on Biology GTAs' teaching anxiety, research anxiety, coping strategies, self-efficacy, career aspirations, and demographics to develop a rich understanding of the graduate student perspective on anxiety as a GTA.

Chapter 1: What factors impact GTA teaching anxiety?

Correlation plots and multiple regression models of the data revealed that greater teaching self-efficacy was related to lower teaching anxiety in Biology GTAs (R_{2adj}=0.67, p<0.001), and coping was positively correlated to self-efficacy. I found no statistical difference in teaching anxiety among genders, ethnicities, student citizenship status (domestic vs. international) and teaching experience level. However, there were some significant differences across student subgroups in teaching self-efficacy and coping strategies. Experienced GTAs had significantly higher instructional self-efficacy than novice GTAs; and non-white, international GTAs had significantly higher coping frequencies compared to white, domestic GTAs. These results suggest that teaching self-efficacy may be important in reducing teaching anxiety, and coping frequency may help to build self-efficacy. Thus, effective coping may be linked to reduced anxiety via increases in self-efficacy, although these specific relationships (particularly for specific subsets of GTAs) need to be further explored.

Chapter 2: How do GTA teaching and research anxieties compare?

Thematic analysis of Biology GTA interview data revealed five major themes characterizing teaching and research anxiety (Chen, Petrie, Schussler, *In review*): impact on self, impact on others, lack of self-efficacy, role tension, and personal anxieties. Results indicated that GTAs' professional roles in teaching and research led to similar anxieties, but in different proportions. One of the most prevalent themes within both teaching and research contexts relate to not having control or lack of self-efficacy in carrying out a task successfully. Examining differences in emergent anxieties among teaching and research, the anxiety of impacting others negatively (e.g. students) through one's teaching, was often the most prominent theme within the teaching

context; while for research, the anxiety related to lack of self-efficacy in carrying out a research task (e.g. data analysis) and anxieties related to impact on self (e.g. one's reputation) were most prevalent. Conflicts between teaching and research also led to anxiety, particularly with regard to time constraints in teaching contexts. One year after the initial interviews, anxieties related to research appeared to decrease more than anxieties related to teaching. Lastly, GTAs with academic career aspirations expressed less anxiety about role tensions or time constraints compared to GTAs with non-academic career goals.

Chapter 3: How do GTAs cope with teaching and research anxieties?

Biology GTAs employed more adaptive coping strategies than maladaptive coping strategies in response to both teaching and research anxieties (Chen Musgrove, Cooley, Feiten, Petrie, Schussler, *In prep*). The most prevalent coping strategies GTAs used to deal with teaching anxiety was problem solving, where GTAs attempt to resolve the stressor causing anxiety, and information seeking, where GTAs learn more about a stressor in order to resolve it. Comparatively, problem solving, information seeking, and support-seeking were the most prevalent coping strategies employed when managing research anxiety. Interestingly, over time, these adaptive coping strategies declined in use among GTAs, though maladaptive strategies did not notably increase. This may indicate a stabilization of coping strategies over time. Lastly, GTAs with both academic and non-academic career goals predominantly relied on adaptive coping strategies although GTAs with academic career aspirations tended to have less fluctuations in coping over a year compared to GTAs with non-academic career aspirations.

Future directions

There is currently no existing literature that explores how teaching anxiety in GTAs impacts student learning. Data could be collected through GTA anxiety surveys and institutional student evaluation reports of GTA participants or common assessments of student learning across multiple sections, in order to further probe undergraduate student perception of that class, identify if anxiety could be observed, and how that may impact their learning. Interview data have also been collected on perception of teaching support and perceptions of GTA teaching effectiveness, which may be used for future studies.

As an extension of my dissertation work, I hope to examine mental health in academia more broadly, and how the current academic environment may incentivize or discourage certain individuals to persist in academia. What interventions may be best implemented to equip graduate students with effective coping strategies? What are the anxieties and coping strategies of Biology instructors and faculty? Is this common across STEM disciplines? Examining anxiety and coping across disciplines among GTAs and faculty would provide further guidance in the development of interventions to reduce teaching or research anxiety and increase adaptive coping mechanisms among college instructors.

Implications

In understanding how GTAs cope with teaching and research anxieties over time and between different career goals, this work can inform future professional development for GTAs, support adaptive coping strategies, and encourage greater awareness and dialogue about the impacts of GTA mental health issues in academia. This knowledge about GTA anxiety, self-efficacy, and coping can be applied at two

different levels: (1) informing professional development initiatives for GTAs; and (2) equipping graduate students, advisors, departments, and institutions with the necessary knowledge to discuss mental health in academia. For example, if GTAs as teachers are anxious about impacting their students negatively, and most GTAs cope though information seeking, we can point to specific strategies during teaching professional development and provide resources for where to best seek information. In research contexts, knowing that GTAs employ support-seeking to cope, we can share with advisors how their support is integral to positive graduate student mental health and encourage them to check-in on their student's well-being. PD coordinators and advisors can also integrate activities in graduate student training for them to build self-efficacy in these coping strategies. GTAs with non-academic career aspirations may also need access to a different set of resources to help them cope through information seeking, especially in discerning career prospects. Pro-active support structures are critical to a positive graduate student experience.

Recent intervention studies have been published to help improve mental health in graduate students. In a study of 231 employed graduate students, Nicklin et al. (2018) explored personal and psychological resources which decrease perceptions of stress. They found that mindfulness, self-compassion, and resilience were negatively related to stress. The need for self-compassion, *"a reflexive process that requires recognizing moments of pain and suffering and practicing critical awareness to explore what's happening,"* is critical for a the doctoral journey (Golnaraghi 2016). Incorporating these activities into graduate student training or professional development, holding community events addressing mental health and open discussion on the topic with

mental health professionals (Mousavi et al. 2018), and such related undertakings can equip GTAs with adaptive coping strategies. Future research may be directed to interventions of mindfulness training as seen for undergraduate students to combat test anxiety (H. Cho et al. 2016; D. W. Nelson and Knight 2010).

From our work, we recommend that graduate students who identify with these anxiety themes try to seek out effective coping strategies from professional counselors to best mitigate the anxieties they experience. Graduate programs must try to encourage more effective coping strategies as students progress through their degree programs, by providing greater access to resources and mental health support to students and customizing these supports depending on their needs. This is important, because learning to cope effectively with teaching and research anxieties may help to reduce attrition in graduate programs and address the epidemic of mental health concerns that graduate students are currently experiencing.

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APPENDIX

BIOLOGY GTA SURVEY ON TEACHING ANXIETY

Q2 This survey is restricted to graduate students who have been a GTA who has served as an instructor in the classroom (e.g. not just grading or lab prep) either at the University of Tennessee or at another institution. Do you meet this criteria?

- ❍ Yes (1)
- ❍ No (2)

Q3 Currently, are you a Teaching Assistant (TA)?

- ❍ Yes (1)
- ❍ No (2)

Display This Question:
If Currently, are you a Teaching Assistant (TA)? = Yes

Q4 What course are you teaching?

_____

Display This Question:
If Currently, are you a Teaching Assistant (TA)? = Yes

Q5 What is your main responsibility as a TA in this course?

- ❑ Instructor with grading (1)
- ❑ Instructor without grading (2)
- ❑ Grader only (3)
- ❑ Other (4) _____

Q6 Have you been a TA in previous semesters? This applies to other institutions as well.

- ❍ Yes (1)
- ❍ No (2)

Skip To: Q11 If Have you been a TA in previous semesters? This applies to other institutions as well. = No

Q7 What role have you predominantly served as a TA over these years?

- ❍ Instructor with grading (1)
- ❍ Instructor without grading (2)
- ❍ Grader only (3)
- ❍ Other (4) _____

Q8 Counting this semester, how many semesters of teaching experience do you have at UTK? (please enter in numeric form)

_____

Q9 Counting this semester, how many total semesters of teaching experience do you have from any university? (if different from above)

_____

Q10 How many total different courses have you taught in total? (if different from above)

_____

Q11 On average, how much time (in hours) do you spend preparing to teach each week for your current or most recent TA assignment? Note: This does not include the TA prep meetings.

_____

Q12 Typically, how many days in advance do you begin to prepare for your class each week? i.e. read lab material, write notes, design a powerpoint, etc.

- ❍ < 1 day (1)
- ❍ 1 (2)
- ❍ 2 (3)
- ❍ 3 (4)
- ❍ 4 (5)
- ❍ > 4 days (6)
- ❍ I don't prepare (7)

Q13 Typically, how much time (in minutes) in advance do you arrive in the classroom/lab to teach?

_____

Q14 Whom do you talk to about preparing to teach your class/lab?

- ❑ My labmates (1)
- ❑ My fellow TAs from that same course (2)
- ❑ Head TA from that same course (9)
- ❑ Other TAs from other courses (3)
- ❑ Lab coordinator (4)
- ❑ My advisor (5)
- ❑ Course director (6)
- ❑ No one (7)
- ❑ Other (8) _____

Q15 Do you usually share ideas and resources (i.e. notes, powerpoints, grading tips) with your fellow TAs?

- ❍ Yes (1)
- ❍ No (2)

Q16 On a scale between 1 and 5, please rate your confidence in your ability to:	Not at all confident (1)	Slightly confident (2)	Somewhat confident (3)	Quite confident (4)	Very confident (5)
Promote student participation in my classes. (1)	❍	❍	❍	❍	❍
Make students aware that I have a personal investment in them and in their learning. (2)	❍	❍	❍	❍	❍
Create a positive classroom climate for learning. (3)	❍	❍	❍	❍	❍
Think of my students as active learners, which is to say knowledge builders rather than information receivers. (4)	❍	❍	❍	❍	❍
Encourage my students to ask questions during class. (5)	❍	❍	❍	❍	❍
Actively engage my students in the learning activities that are included in the teaching plan/syllabus. (6)	❍	❍	❍	❍	❍
Promote a positive attitude towards learning in my students. (7)	❍	❍	❍	❍	❍
Provide support/encouragement to students who are having difficulty learning. (8)	❍	❍	❍	❍	❍
Encourage the students to interact with each other. (9)	❍	❍	❍	❍	❍

Q17 On a scale between 1 and 5, please rate your confidence in your ability to:	Not at all confident (1)	Slightly confident (2)	Somewhat confident (3)	Quite confident (4)	Very confident (5)
Show my students respect through my actions. (10)	❍	❍	❍	❍	❍
Let students take initiative for their own learning. (11)	❍	❍	❍	❍	❍
Appropriately grade my students' exams/assignments. (12)	❍	❍	❍	❍	❍
Evaluate accurately my students' academic capabilities. (13)	❍	❍	❍	❍	❍
Prepare the teaching materials I will use. (14)	❍	❍	❍	❍	❍
Spend the time necessary to plan my classes. (15)	❍	❍	❍	❍	❍
Clearly identify the course objectives. (16)	❍	❍	❍	❍	❍
Provide my students with detailed feedback about their academic progress. (17)	❍	❍	❍	❍	❍
Stay current in my knowledge of the subject I am teaching. (18)	❍	❍	❍	❍	❍

Q18 Based on your experience as a GTA, please rate the frequency on the following:	Never (1)	Infrequently (2)	Occasionally (3)	Frequently (4)	Always (5)
I feel calm and collected when I think about meeting with a student for office hours. (1)	❍	❍	❍	❍	❍
If I have trouble answering a student's question I find it difficult to concentrate on questions that follow. (2)	❍	❍	❍	❍	❍
I feel uncomfortable when I speak before a group. (3)	❍	❍	❍	❍	❍
I feel calm when I am preparing lessons. (4)	❍	❍	❍	❍	❍
I'm worried whether I can be a good teacher. (5)	❍	❍	❍	❍	❍
I feel sure I will find teaching a satisfying profession. (6)	❍	❍	❍	❍	❍

I would feel calm and collected being observed in my classroom. (7)	❍	❍	❍	❍	❍
I feel inferior to other GTAs who are teaching. (8)	❍	❍	❍	❍	❍
I feel that students will follow my instructions. (9)	❍	❍	❍	❍	❍
I feel secure with regard to my ability to keep a class under control. (10)	❍	❍	❍	❍	❍

Q19 Based on your experience as a GTA, please rate the frequency on the following:	Never (1)	Infrequently (2)	Occasionally (3)	Frequently (4)	Always (5)
I'm less happy teaching than I thought I'd be. (11)	❍	❍	❍	❍	❍
I feel nervous when I am being observed by my college supervisor. (12)	❍	❍	❍	❍	❍
I feel confident about my ability to improvise in the classroom. (13)	❍	❍	❍	❍	❍
I feel other teachers think I'm very competent. (14)	❍	❍	❍	❍	❍
I feel panicky when a student asks me a question I can't answer. (15)	❍	❍	❍	❍	❍

I feel anxious because I don't know yet whether I really want to be a teacher. (16)	❍	❍	❍	❍	❍
I feel better prepared for teaching than other TAs. (17)	❍	❍	❍	❍	❍
Lack of good rapport with my students is one of my biggest worries. (18)	❍	❍	❍	❍	❍
I would feel anxious if the course director came to observe my class (19)	❍	❍	❍	❍	❍
I find it easy to speak up in the lab preparation meetings. (20)	❍	❍	❍	❍	❍

Q20 Based on your experience as a GTA, please rate the frequency on the following:	Never (1)	Infrequently (2)	Occasionally (3)	Frequently (4)	Always (5)
I worry about being able to keep the students interested in what I teach them. (21)	❍	❍	❍	❍	❍
I find it easy to admit to the class that I don't know the answer to a question a student asks. (22)	❍	❍	❍	❍	❍
Deciding how to present information in the classroom makes me feel uncertain. (23)	❍	❍	❍	❍	❍
I feel I will have good recall of the things I know when I am in front of the class. (24)	❍	❍	❍	❍	❍

I feel I am as competent in the classroom as other TAs in my program. (25)	❍	❍	❍	❍	❍
I'm concerned about how to use my testing of students as a useful indication of how effectively I'm teaching them. (26)	❍	❍	❍	❍	❍
I'm worried that differences in background between my students and me prevent me from teaching effectively. (27)	❍	❍	❍	❍	❍
I am certain that my own personal "hang-ups" do not hinder my teaching effectiveness. (28)	❍	❍	❍	❍	❍

I'm uncertain whether I can tell the difference between really seriously disturbed students and those who are merely "goofing off" in class. (29)	❍	❍	❍	❍	❍

Q21 Based on your experience as a biology graduate student, please indicate how frequently you enact these activities before teaching:	1 - Never (1)	2 (2)	3 (3)	4 (4)	5 - Always (5)
Spend significant time making sure you really know the lesson/course content. (1)	❍	❍	❍	❍	❍
Spend significant time engaging in procedures for deep muscular relaxation. (2)	❍	❍	❍	❍	❍
Spend significant time visualizing participating in different communication situations while in deep relaxation. (3)	❍	❍	❍	❍	❍
Spend time going over and over the class material. (4)	❍	❍	❍	❍	❍
Spend specific time identifying negative statements/thoughts you have about yourself. (5)	❍	❍	❍	❍	❍
Spend significant attention and effort toward eliminating your irrational and negative self thoughts. (6)	❍	❍	❍	❍	❍

Spend specific time replacing your negative self thoughts with positive self thoughts. (7)	❍	❍	❍	❍	❍
Practice saying and thinking positive self thoughts about yourself. (8)	❍	❍	❍	❍	❍
Practice actually what you are going to say to your students. (9)	❍	❍	❍	❍	❍
Practice how you are going to say what you are going to say to your students. (10)	❍	❍	❍	❍	❍
Practice actually delivering your entire lesson. (11)	❍	❍	❍	❍	❍
Practice making your voice loud enough to be heard. (12)	❍	❍	❍	❍	❍

Q22 Based on your experience as a biology graduate student, please indicate how frequently you enact these activities before teaching:	1 - Never (1)	2 (2)	3 (3)	4 (4)	5 - Always (5)
Practice moving around the room while you teach. (13)	❍	❍	❍	❍	❍
Practice maintaining good eye contact. (14)	❍	❍	❍	❍	❍
Practice making your voice varied in pitch and rate. (15)	❍	❍	❍	❍	❍
Practice gesturing and moving around the room. (16)	❍	❍	❍	❍	❍
Examine your delivery weaknesses and practice making these better. (17)	❍	❍	❍	❍	❍

Practice thinking positively about teaching in front of your students. (18)	❍	❍	❍	❍	❍
Visualize yourself successfully teaching your class. (19)	❍	❍	❍	❍	❍
Visualize students positively responding to your teaching. (20)	❍	❍	❍	❍	❍
Picture yourself successfully going through an entire class day. (21)	❍	❍	❍	❍	❍
Visualize yourself as full of energy and confidence as you approach and teach your class. (22)	❍	❍	❍	❍	❍

Spend extra time talking to experienced TAs and Faculty regarding how to teach well. (23)	❍	❍	❍	❍	❍
Spend extra time talking to the course director or TA supervisor about how to teach well. (24)	❍	❍	❍	❍	❍

Q23 Let's assume teaching and research together represent 100% of your work time, what percent do you spend doing each? Note: Answers must total 100.
Teaching (preparation and grading, etc.) : _____ (2)
Research : _____ (1)
Total : _____

Q24 If you could choose the percent of time you spent on teaching and research, what would it be? Note: Answers must total 100.
Teaching (preparation and grading, etc.) : _____ (2)
Research : _____ (1)
Total : _____

Q25 On a scale from 1 (Not supportive) to 5 (Very supportive), please rate:

	1 - Not supportive (1)	2 (2)	3 (3)	4 (4)	5 - Very supportive (5)
⊗How supportive you think your department is of graduate student teaching. (4)	❍	❍	❍	❍	❍

Q26 On a scale from 1 (Not anxious) to 5 (Very anxious), how anxious are you:

	1 - Not anxious (1)	2 (2)	3 (3)	4 (4)	5 - Very anxious (5)
About being a graduate student/the graduate student experience (Q22_1)	❍	❍	❍	❍	❍
Being a TA in your most recent teaching assignment (Q22_2)	❍	❍	❍	❍	❍
Being a TA generally (Q22_3)	❍	❍	❍	❍	❍
In your daily life generally (Q22_4)	❍	❍	❍	❍	❍

Q27 Generally, how do you cope with anxiety?

_____

_____

_____

_____

_____

Q28 Please state your age.

_____

Q29 What is your gender?

- ❍ Male (1)
- ❍ Female (2)
- ❍ Open response (3) _____

Q30 What is your racial/ethnic identity?

_____

Q31 Please state your residency status. If you are an international student, please include your home country.

- ❍ Domestic student (1)
- ❍ International student (2) _____

Q32 What graduate degree are you pursuing?

- ❍ Master's (1)
- ❍ PhD (2)
- ❍ Other (3) _____

Q33 What year of the degree program are you in?

- 1 (1)
- 2 (2)
- 3 (3)
- 4 (4)
- > 4 (5)

Q34 What department/program are you affiliated with?

- Biochemistry & Cellular and Molecular Biology (BCMB) (1)
- Ecology & Evolutionary Biology (EEB) (2)
- Genome Science & Technology (GST) (3)
- Microbiology (4)
- Other (5) _____

Q35 Please state your unique UTK NetID (i.e. jdoe21).

_____

Q36 Are you interested in volunteering to participate in a brief follow-up interview?

(Note: Participants for the interview will also be compensated for their time!)

- Yes (1)
- No (2)

Display This Question:
If Are you interested in volunteering to participate in a brief follow-up interview? (Note: Partici... = Yes

Q37 Please enter **your name and institutional email** below. Your willingness to participate is very much appreciated!

- Name (5) _____
- Email (6) _____

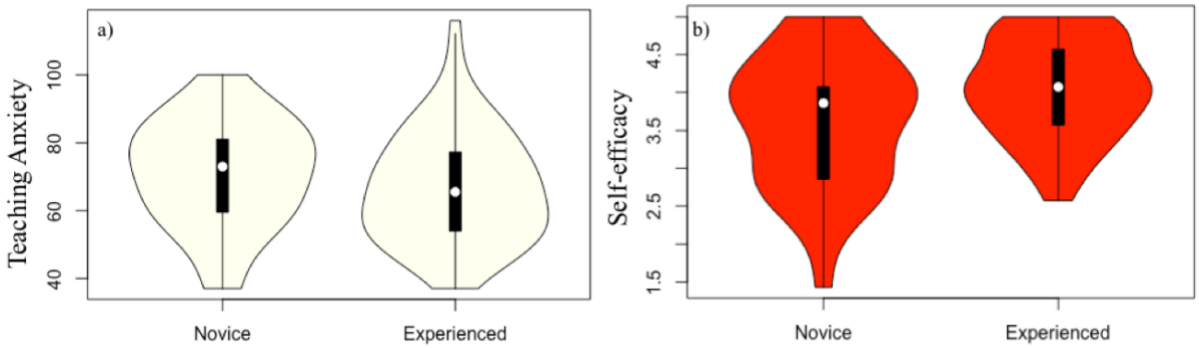
End of Block: Questions

SUPPORTING INFORMATION FOR CHAPTER 1

Differences in teaching anxiety, self-efficacy, and coping among GTA subgroups

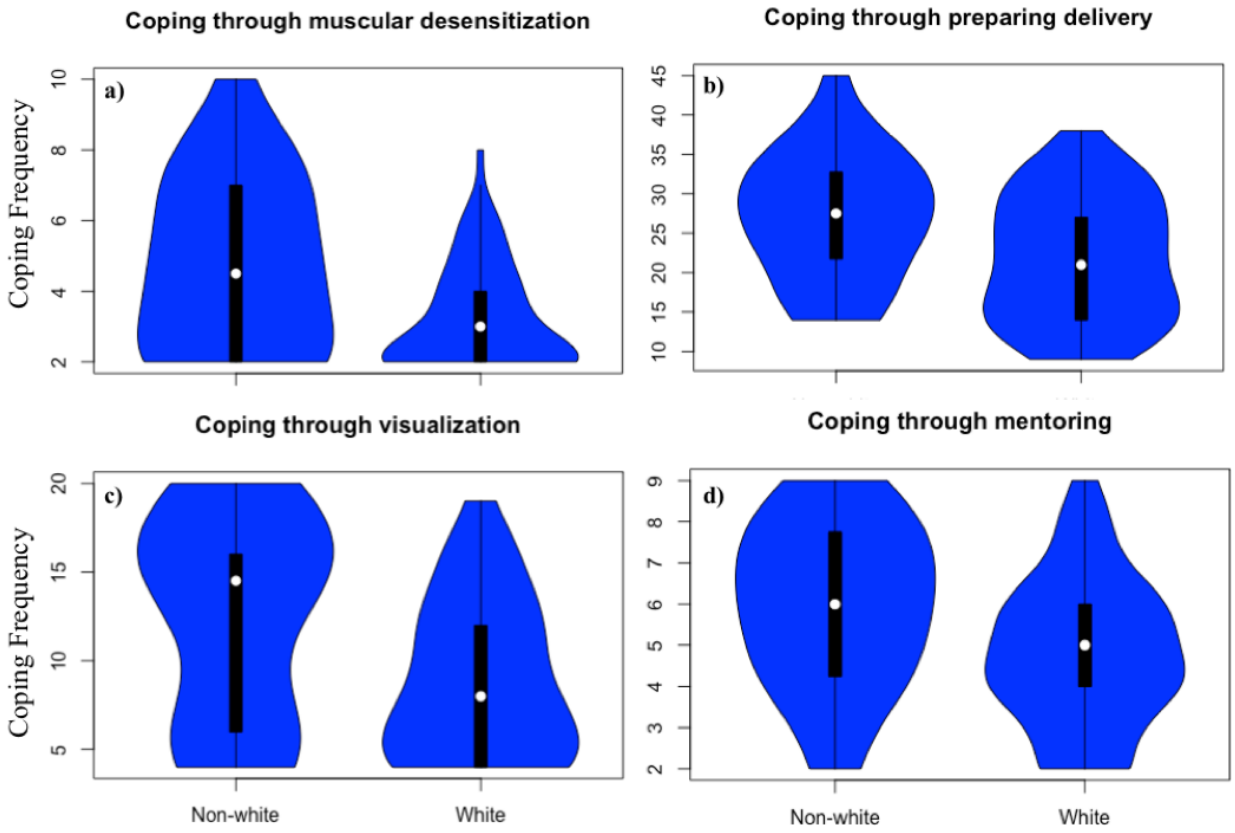
Teaching Anxiety. There were no significant differences in teaching anxiety between GTAs of different genders, ethnicities, departments, year of study, or teaching experience level (see **Appendix Figure 1a** below).

Self-efficacy. There were differences among the GTAs' self-efficacy: experienced GTAs had significantly higher instructional self-efficacy (t=-2.28, p<0.05) than novice GTAs (**Appendix Figure 1b**). This difference was not found in the learning environment self-efficacy construct. There were no other significant differences in teaching self-efficacy between other subgroups.



Appendix Figure 1: Differences in **a) teaching anxiety** (t=1.2, *ns*) and **b) instructional self-efficacy** (t=-2.3, p<0.05) between novice and experienced GTAs. Experienced GTAs (=4.0±0.64) had significantly higher instructional self-efficacy than novice GTAs (=3.6±0.87). There were no significant differences found between Novice and Experienced GTAs for the learning environment self-efficacy construct.

Coping. Comparing differences in coping strategies between subgroups, we found significant differences between student citizenship status subgroups (domestic vs. international) and Ethnic (white vs. non-white) groups. There was high overlap between these two subgroups; 91% percent of the white GTA population were also domestic students, and 83% of the non-white GTAs were international students. Because of this overlap, we chose to compare only ethnicity to further examine trends in coping, since using both subgroup categories (ethnicity and citizenship) would be highly redundant. We chose to examine ethnicity over citizenship status as there is more literature to support differences in coping and anxiety between ethnic majority and minority groups (El-Ghoroury et al. 2012), compared to the literature on citizenship status. We found significant differences between non-white (n=26) and white (n=63) GTAs (**Appendix Figure 2**). Non-white groups coped significantly more often than their white counterparts. These coping strategies included **a) muscular desensitization** (t=2.93, p<0.001), **b) preparing delivery** (t=2.90, p<0.001), **c) visualization of oneself teaching successfully** (t=2.86, p<0.001) and **d) seeking mentoring (**t=2.68, p<0.05; for further details about these coping strategies, see Methods).

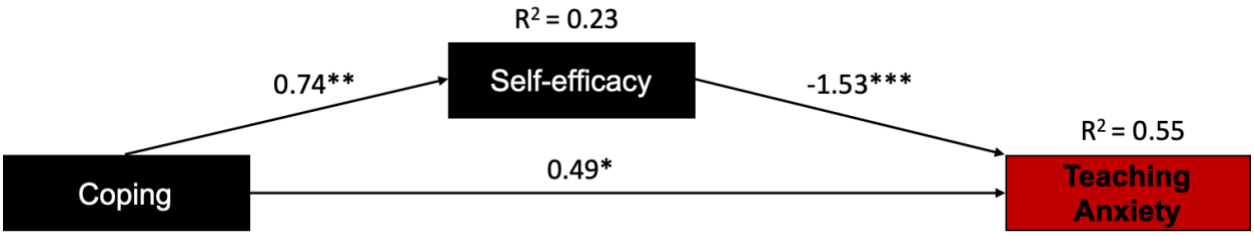


Appendix Figure 2: Significant differences in coping between non-white (n=26) and white (n=63) groups. Non-white groups coped significantly more than their white counterparts for these coping strategies. These coping strategies included **a) muscular desensitization** ($\Delta\bar{x}$=1.5, t=2.93, p<0.001), **b) preparing delivery** ($\Delta\bar{x}$=5.4, t=2.90, p<0.0001), **c) visualization of oneself teaching successfully** ($\Delta\bar{x}$=3.5, t=2.86, p<0.001), **d)** mentoring ($\Delta\bar{x}$=1.2, t=2.68, p<0.05).

Structural Equation Modelling (SEM) to test mediation of teaching self-efficacy between coping and teaching anxiety

We found support of the direct relationships for our multiple linear regression models in the SEM model (**Appendix Figure 3**). Self-efficacy and coping together significantly explained 55% of the variance in teaching anxiety (R_2 = 0.55, p<0.001). Also, coping frequency significantly explained 23% of the variance in teaching self-efficacy (R_2 = 0.23, p<0.01).

However, model fit indices indicated that the data did not fully support the theoretical model that teaching self-efficacy is an important mediator between coping and teaching anxiety ($\chi_2[df = 25] = 70.8$, $p < 0.001$; RMSEA = 0.144, CFI = 0.846). Though Hu and Bentler (1999) suggest that CFI > 0.95 and RMSEA < 0.06 indicate acceptable model fit, these guidelines are not absolute and can depend on various modeling conditions (DeChenne et al. 2015). For example, other modelling studies have found that RMSEA between 0.08 and 0.10 is indicative of mediocre model fit (MacCallum, Browne, and Sugawara 1996). Small sample size (n=89) in our study is likely a limiting factor when running our SEM models, as SEMs require robust sample sizes.



Appendix Figure 3: Structural Equation Model predicting teaching anxiety between coping frequency measures and teaching self-efficacy. Model fit indices the data did not fully support the theoretical model ($\chi_2[df = 25] = 70.8$, $p < 0.001$; RMSEA = 0.144, CFI = 0.846).

BIOLOGY GTA INTERVIEW PROTOCOL

Before you read this, read the informed consent for interview participants, and have them sign the general consent and audio record consent on the back. Then, proceed to this sheet.

The questions I am going to ask you today are about four specific topics regarding your teaching: your experience in teaching, perceptions of teaching and research anxiety, the coping strategies you enact (this just means to manage your anxiety level to decrease it), and your current career aspirations. There are no right or wrong answers to these questions, and these responses are completely confidential – I just want to gain your perspective about these ideas!

A) Career/Identity
The first thing I'd like you to do is to take a moment and write down your top two current career aspirations. We'll revisit this again at the end.

B) Teaching experience, knowledge, and attitudes
This portion of the interview will cover general experience and perceptions of teaching.

****** *Interviewees will have a scale in front of them with three pieces of post-it paper to rank: Experience, Knowledge and Attitude. They will be ranking themselves and explaining their choices.*

1. Do you consider yourself to be an experienced teacher? On a scale 1 to 10, 1 indicating little experience and 10 being highly experienced, how would you rate yourself?

2. Based on your experience, on the same scale, 1 representing little knowledge and 10 being highly knowledgeable, how would you rate yourself on knowledge in teaching. This can be from pedagogical knowledge, to assessment design, etc.

3. On a scale 1 to 10, 1 indicating very negative and 10 being very positive, how would you rate your attitude toward teaching.

4. Please explain your choices.

C) Teaching and Research Anxiety
5. Before jumping into the next question, I'd like you to take a minute and list a few things that make you anxious (if you have any) about teaching and research.

***have them complete this on the prepared piece of paper with the career aspirations as well*

Thank you. To continue, we're going to look at these cards and identify aspects of teaching that may cause you anxiety. This protocol is still in development, so feel free to create your own cards and add to the list.

Layout cards in front of participants randomly. Use cards to have them select things that make them anxious (or create own cards) and have them rank (1 being most anxious).* ***If they do not pick a card, skip to 5d.

a. What about each choice specifically that make you anxious?
b. How do you think anxiety impacts your teaching for each? +/-/0
c. How you cope (if you do cope) with these things for each?
d. You did not choose any cards that make you anxious, why is that? Do you consider yourself not a very anxious person or have specific coping strategies you use?

6. Does the research you are conducting as part of your graduate program ever make you feel anxious? And for this question, we're going to look at these cards and identify aspects that may cause you anxiety. Not all cards will represent what you are anxious about, so again, feel free to add to the list.

Layout card in front of participants randomly. Use cards to have them select things that make them anxious (or create own cards) and have them rank (1 being most anxious).* ***If they do not pick a card, skip to 6d.

a. Generally, what about these choices specifically make you anxious?
b. How do you think anxiety impacts your research? +/-/0
c. How do you cope (if you do) with these things?
d. You did not choose any cards that make you anxious, why is that? Do you consider yourself not a very anxious person or have specific coping strategies you use?

*****If there are rankings for BOTH teaching and research anxiety proceed to Q7. If not continue to Q8.***

7. We have this list of things that make you anxious about teaching, and this list of things that make you anxious about research. What I want you to do now is rank ALL these cards according to what causes you the most down to the least anxiety OVERALL in grad school.

***use cards to have them ranks things that make them anxious (or create own cards) from the first two sets.*

a. So it looks like [teaching / research / a mixture of both] cause you the most anxiety in grad school. Why is that?
b. Does your teaching anxiety impact your research anxiety? If so, how?
c. Does your research anxiety impact your teaching anxiety? If so, how?

d. Do you have any other sources of anxiety in grad school?

8. Would you want graduate school (teaching and research) to cause you no anxiety? Why or why not?

D) Revisiting career aspirations/identity and attrition

9. Revisiting your top career aspirations, what are they and why did you choose them? Assume the world is your oyster—would they be the same? i.e. not influences by anything like the job market, etc.

10. Does your anxiety about teaching/research/both make you second guess or question your career options? And if so why?

11. How likely could the anxiety that you feel in teaching, research, or both cause you to consider leaving the program?

12. Do you have any other thoughts about being a graduate student, anxiety, teaching, research, etc. you would like to share?

Thank you!

Have students complete the compensation form and then sign the compensation consent line on the informed consent sheet.

A) Career aspirations

1.

2.

C) Anxieties

Teaching Anxiety	Research Anxiety

CARDS IDENTIFYING TEACHING ANXIETY

Student issues/Emergency situations

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Time away from other priorities

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Supporting effective student learning

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Feedback/complaints about teaching

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Interactions with teaching supervisors

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Being observed teaching by a peer

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Living off my stipend

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Reading student evaluations

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Attending TA Meetings

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Being observed teaching by the course instructor

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Writing quizzes, exams, or other graded assignments

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Not knowing the topic

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Answering student questions by email

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Time to prepare for teaching

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Time to complete a class activity

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Not knowing best teaching practices to use

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Grading

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Student behavior

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Teaching labs/discussion itself

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Advisor pushback/support

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Seeing students outside of class

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Meeting students for office hours

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Answering student questions in class

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Preparing to teach for an undergrad lab/class

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Being unable to answer a student's question

Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

Speaking in front of the classroom			Being evaluated by the course instructor/staff/faculty for your teaching		
Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G	Anxiety_T	Anxiety impact on teaching (+/-/0)?	Anxiety_G

CARDS IDENTIFYING RESEARCH ANXIETY

Meeting departmental deadlines Anxiety_R | Anxiety_G	Leading my own project Anxiety_R | Anxiety_G
Time management Anxiety_R | Anxiety_G	Anxiety_R | Anxiety_G

Uncertainty of project success

Anxiety_R	Anxiety_G

Anxiety_R	Anxiety_G

Meeting your advisor

Anxiety_R	Anxiety_G

Leading lab meeting

Anxiety_R	Anxiety_G

Writing (e.g. proposals, grants, manuscripts)

Anxiety_R	Anxiety_G

Giving a seminar talk

Anxiety_R	Anxiety_G

Being reviewed by your advisor

Anxiety_R	Anxiety_G

Being unable to answer a question posed by a peer

Anxiety_R	Anxiety_G

Being unable to answer a question posed by my advisor/faculty

Anxiety_R	Anxiety_G

Living off your stipend

Anxiety_R	Anxiety_G

Attending lab meetings

Anxiety_R	Anxiety_G

Doing data analysis

Anxiety_R	Anxiety_G

Conducting lab/field work

Anxiety_R	Anxiety_G

Applying for grants, fellowships

Anxiety_R	Anxiety_G

Reading/understanding papers

Anxiety_R	Anxiety_G

Thinking about life after grad school

Anxiety_R	Anxiety_G

Interactions with lab mates

Anxiety_R	Anxiety_G

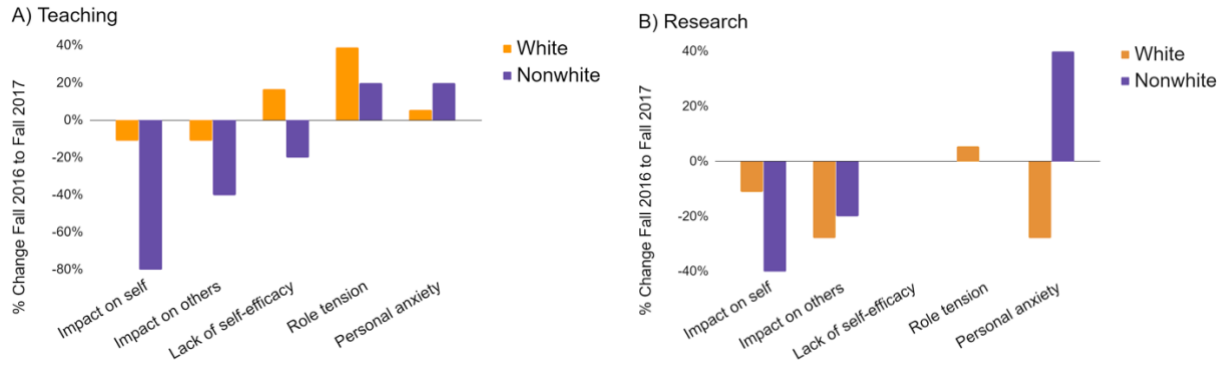
Being asked questions during a presentation

Anxiety_R	Anxiety_G

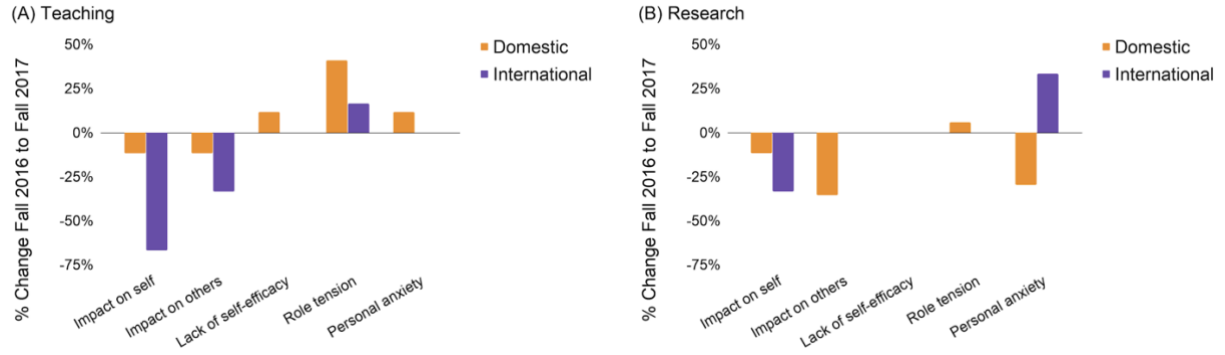
Interactions with faculty

Anxiety_R	Anxiety_G

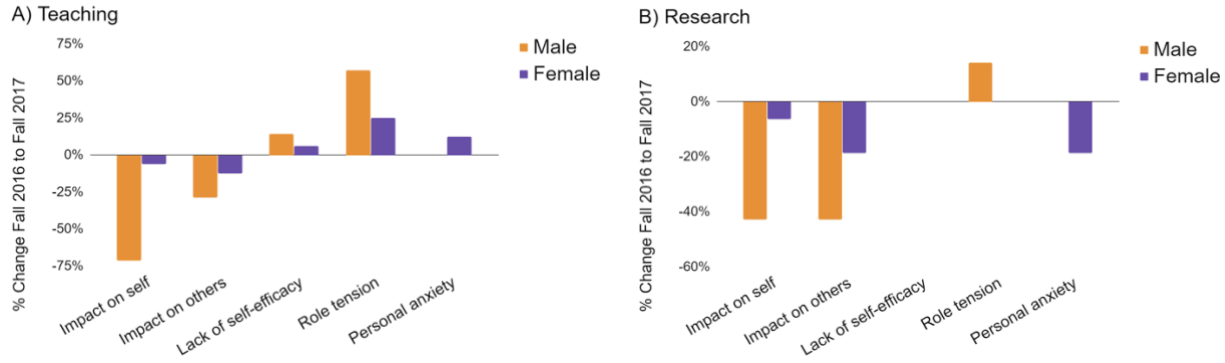
Anxiety_R	Anxiety_G



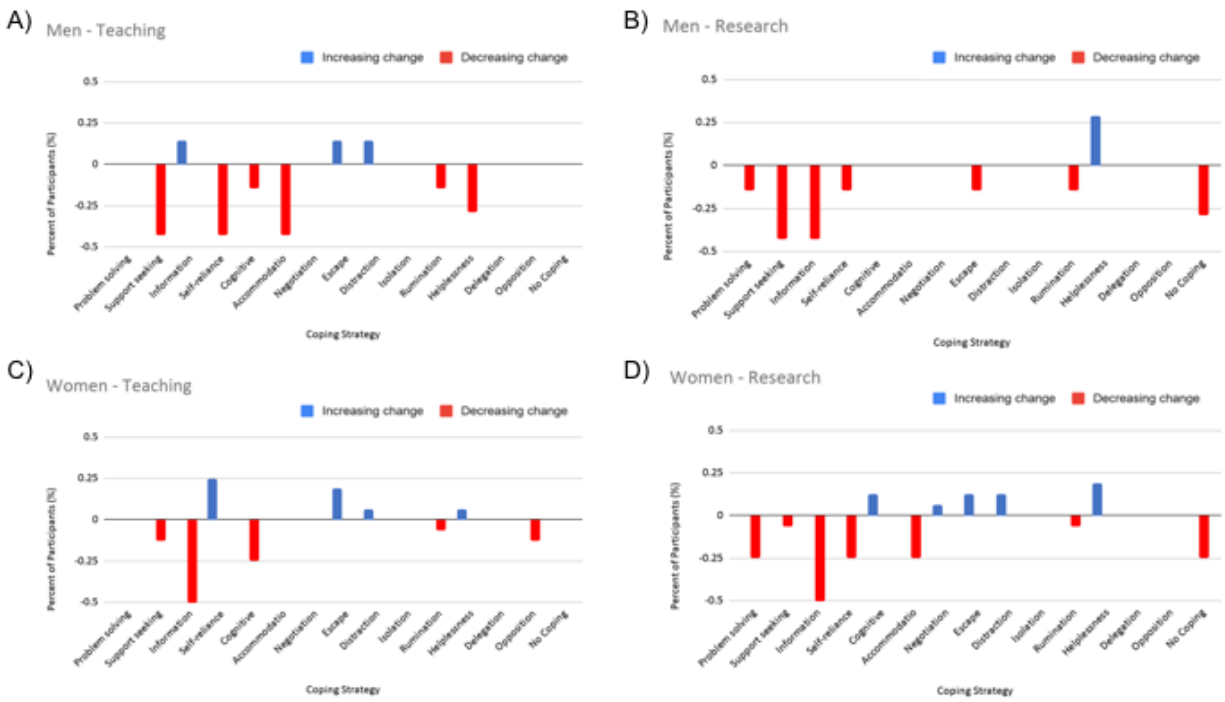
Appendix Figure 4: Comparing the percentage change of (A) Teaching and (B) Research anxiety between ethnicity (white vs. nonwhite) of GTAs from Fall 2016 to Fall 2017.



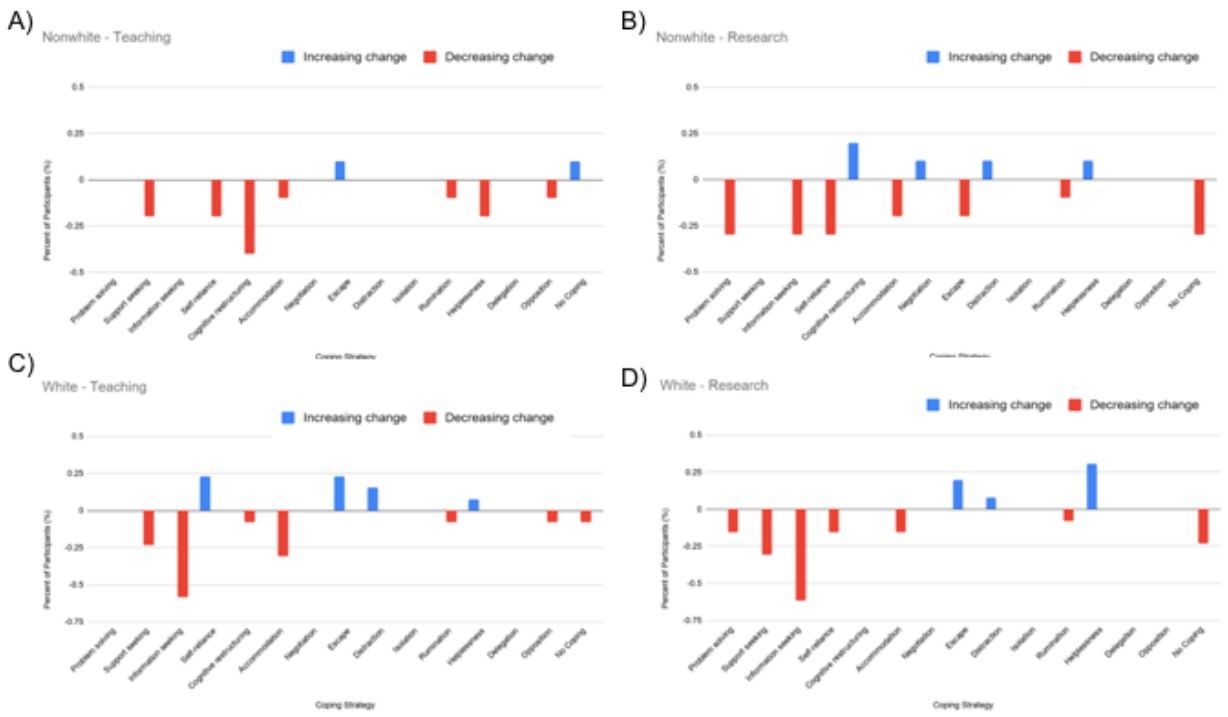
Appendix Figure 5: Comparing the percentage change of (A) Teaching and (B) Research anxiety between citizenship status (international vs. domestic) of GTAs from Fall 2016 to Fall 2017.



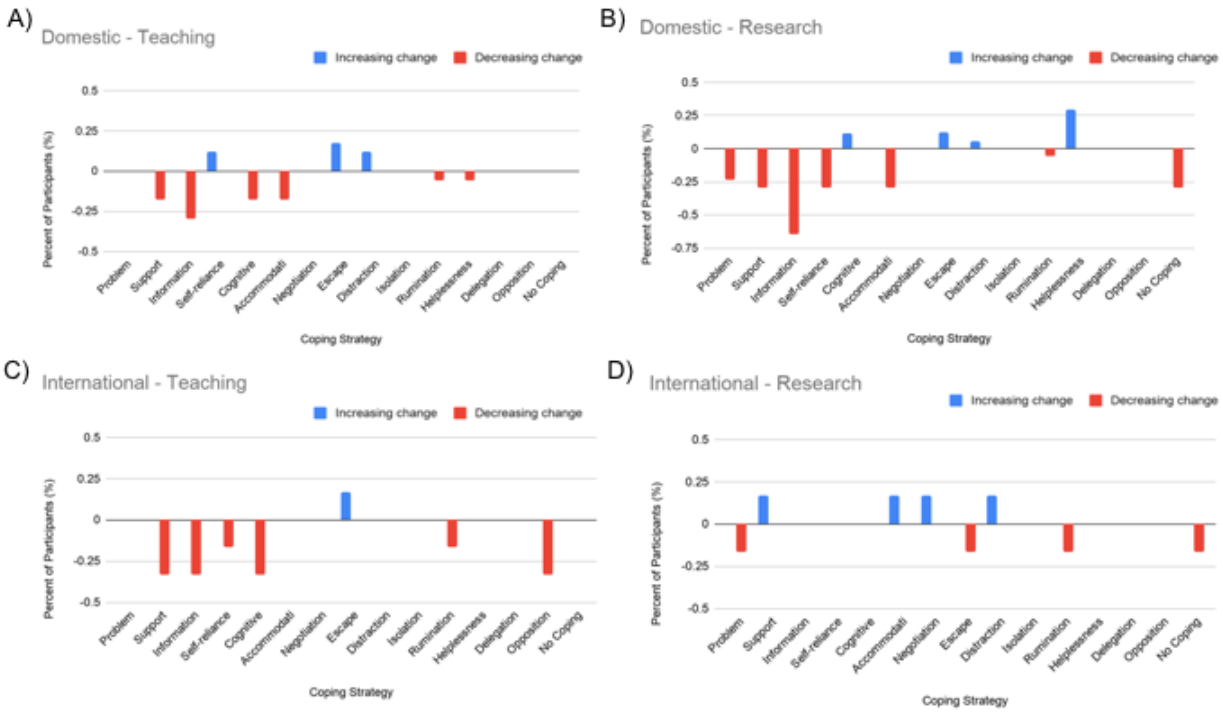
Appendix Figure 6: Comparing the percentage change of (A) Teaching and (B) Research anxiety between gender (men vs. women) of GTAs from Fall 2016 to Fall 2017.



Appendix Figure 7: Coping strategies between male and female GTAs from 2016-2017. Graphs display how **A)** coping with teaching anxiety and **B)** coping with research anxiety changed among male GTAs over one year; and how **C)** coping with teaching anxiety and **D)** coping with research anxiety changed among female GTAs over one year.



Appendix Figure 8: Coping strategies between nonwhite and white GTAs from 2016-2017. Graphs display how **A)** coping with teaching anxiety and **B)** coping with research anxiety changed among nonwhite GTAs over one year; and how **C)** coping with teaching anxiety and **D)** coping with research anxiety changed among white GTAs over one year.



Appendix Figure 9: Coping strategies between domestic and international GTAs from 2016-2017. Graphs display how **A)** coping with teaching anxiety and **B)** coping with research anxiety changed among domestic GTAs over one year; and how **C)** coping with teaching anxiety and **D)** coping with research anxiety changed among international GTAs over one year.

VITA

Miranda Maan Lin Chen Musgrove was born and raised in Toronto, Ontario, where she earned her B.Sc. with Honors in Biology, minoring in Environmental Studies at York University. At the end of her undergrad, thinking she wanted to be a conservation manager of some sort, Miranda sought out her M.Sc. with Dr. Sapna Sharma, examining the impacts of projected climate change on the distributions of cisco, an important forage prey fish. Though becoming an ecological modeler was a lot of fun, Miranda found her passion for teaching, mentoring, and working with people. Two weeks after defending her M.Sc., she packed up and moved south to work with Dr. Beth Schussler in science education research. She graduated with a Doctor of Philosophy in Ecology and evolutionary Biology in Summer 2020. She is continuing her research scholarship in a post-doctoral position at the University of Colorado, Boulder with Dr. Lisa Corwin. Outside of work, you can find Miranda volunteering with her local Catholic Church, experimenting with a new recipe, or preparing her tiny house for her first-born son with her husband.