Toward More Inclusive Large-Enrollment Undergraduate Biology Classrooms:

Identifying Inequities and Possible Underlying Mechanisms

by

Katelyn M. Cooper

A DissertationPresented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Approved April 2018 by the
Graduate Supervisory Committee:

Sara Brownell, Chair
James Collins
Miles Orchinik
Valerie Stout
Yi Zheng

ARIZONA STATE UNIVERSITY

May 2018

ABSTRACT

Guided by Tinto's Theory of College Student Departure, I conducted a set of five studies to identify factors that influence students' social integration in college science active learning classes. These studies were conducted in large-enrollment college science courses and some were specifically conducted in undergraduate active learning biology courses. Using qualitative and quantitative methodologies, I identified how students' identities, such as their gender and LGBTQIA identity, and students' perceptions of their own intelligence influence their experience in active learning science classes and consequently their social integration in college. I also determined factors of active learning classrooms and instructor behaviors that can affect whether students experience positive or negative social integration in the context of active learning. I found that students' hidden identities, such as the LGBTQIA identity, are more relevant in active learning classes where students work together and that the increased relevance of one's identity can have a positive and negative impact on their social integration. I also found that students' identities can predict their academic self-concept, or their perception of their intelligence as it compares to others' intelligence in biology, which in turn predicts their participation in small group-discussion. While many students express a fear of negative evaluation, or dread being evaluated negatively by others when speaking out in active learning classes, I identified that how instructors structure group work can cause students to feel more or less integrated into the college science classroom. Lastly, I identified tools that instructors can use, such as name tents and humor, which can positive affect students' social integration into the college science classroom. In sum, I highlight inequities in students' experiences in active learning science classrooms and the

mechanisms that underlie some of these inequities. I hope this work can be used to create more inclusive undergraduate active learning science courses.

DEDICATION

To my family, especially my mom, dad, sister, and grandparents, for supporting me throughout my many academic journeys and for encouraging me at every point along the way to pursue my passions. To the mentors, colleagues, and students who have challenged my assumptions and caused me to think more critically about equity and access.

ACKNOWLEDGMENTS

First and foremost, I would like to acknowledge my advisor, Dr. Sara Brownell, for being the most phenomenal mentor. I thank her for sharing her brilliant thoughts with me on many occasions, for challenging my thinking, for modeling an extraordinary work ethic, and for developing my passion for equity and access in undergraduate biology education. If it were not for her remarkable patience, infinite wisdom, and exceptional mentoring in both teaching and research, I would not be where I am today.

I thank Dr. Miles Orchinik for sparking my interest in undergraduate biology education and Scot Shoenborn for encouraging me to explore such interest and for giving me the flexibility I needed to begin this journey. I appreciate Dr. Valerie Stout for sharing her knowledge about teaching with me and for providing consistent encouragement throughout my time at ASU. I thank Dr. Jim Collins for his helpful advice and for his profound insights about higher education. Also, I thank Dr. Yi Zhang for her advisement on projects and for her willingness to serve as my mentor in statistics and analyses.

I am very grateful for my collaborators, especially Dr. Paula Soneral and Virginia Downing, for their thoughtful contributions to our work. I also acknowledge the former students who began as undergraduate researchers and emerged as talented collaborators: Michael Ashley, Anna Krieg, Taija Hendrix, and Michelle Stephens. Their outstanding efforts and notable insights greatly strengthened our research.

Finally, I am especially grateful to my colleague and friend, Liz Barnes, who went on this journey with me and, because of her many successes and thoughtful contributions to the field, challenged me to be better at every point along the way. I am also very

thankful for and indebted to all of the members of the Biology Education Research Lab for supporting me throughout this journey and for always helping to improve my research.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

Table Page

LIST OF FIGURES

Figure Page

Figure Page

CHAPTER 1

INTRODUCTION

A major focal point for exploring student retention in college has been the degree to which students are socially integrated (Tinto, 1975, 1997). Studies have shown that the greater the social integration, the more likely a student is to persist in college (Pascarella & Chapman, 1983; Pascarella, Smart, & Ethington, 1986; Pascarella & Terenzini, 1983). Although social integration was initially conceptualized as interactions among students and between students and faculty outside of class, the transformation of undergraduate courses into active learning spaces created novel opportunities for students to be able to socially integrate during the normal class time (Braxton, Milem, & Sullivan, 2000). This has been argued to be particularly important for non-residential commuter campuses where students may only interact with other students and instructors in the context of a classroom (Braxton et al., 2000). However, there has been limited research done on how active learning can lead to social integration and factors that can influence the degree to which opportunities for social integration can lead to positive social integration.

The overarching theme of my thesis represents an effort towards a better understanding of how active learning can lead to social integration. The increased number of interactions among students and between students and instructors in active learning classrooms has the potential to increase social integration. However, characteristics of the students, characteristics of the other students they are working with in class, and how active learning is implemented likely affect the extent to which an individual student feels socially integrated. I would argue that active learning does not

result in positive social integration as a default, but could result in positive, negative, or neutral social integration. However, active learning does provide increased opportunities for social integration that traditional lecture courses cannot offer and that this may be especially prudent for commuter students at large, non-residential institutions (Braxton et al., 2000).

In this introduction to my thesis, I will describe the literature on social integration and how active learning could lead to social integration, but also how active learning may not necessarily lead to social integration. Finally, I will present a brief synopsis of the five studies that comprise my thesis and highlight how they relate to social integration.

STUDENT PERSISTENCE IN SCIENCE

Student persistence in college science is a pressing concern. The President's Council of Advisors on Science and Technology (PCAST) report has called for a million more STEM majors (Olson & Riordan, 2012), but 48% of college science majors who begin their college experience as a science major do not finish (Chen, 2012) . Even more concerning is that there are often differences in who stays and who leaves: more privileged backgrounds impact whether students stay at a 4-yr college past one year (Aughinbaugh, 2008). It has been shown that students from lower socioeconomic statuses have to work more during college, which correlates with studying less and having a lower grade point average (GPA) (Walpole, 2003), factors that can influence persistence in rigorous science coursework. Graduation rates also differ based on race: Specifically in STEM, white students are more likely to complete their degree (43.9%) than Black students (31.7%) or Hispanic students (33.1%) (Chen, 2009). Further, students' whose parents earned a Bachelor's degree or higher (50.8%) are more likely to

obtain a STEM degree than students whose parents had only some college (32.9%) (Chen, 2009)

Low persistence in college science may in part be due to college science courses, particularly introductory courses, being large and impersonal (Barr, Gonzalez, & Wanat, 2008; Crisp, Nora, & Taggart, 2009; Seymour & Hewitt, 1997). Students may feel invisible and "just a number" because of the large class sizes. Further, science instructors have been described as "chilly" and "unapproachable" (Seymour & Hewitt, 1997). Students may struggle to build connections with other students in the course, as well as the instructor. Although office hours can be used by students to get to know instructors in large classes, students who are commuters and working at the same time as going to school may not be able to attend these office hours. This lack of social integration into the campus community has been proposed to be a factor that hinders student retention in college (Pascarella & Chapman, 1983; Pascarella & Terenzini, 1983; Tinto, 1975, 1997).

TINTO'S THEORY OF COLLEGE STUDENT DEPARTURE

Tinto's 1975 student integration model related to student persistence is often viewed as what sparked a national dialogue about student retention. Vincent Tinto's original theory of college student departure conceptualized two factors that positively influenced student retention in college: academic integration and social integration (Tinto, 1975). He argued that students who academically integrate into their institution and students who socially integrate into their institution will persist; students may not persist in college due to a lack of integration in one or both of those areas. However, refinements to his theory over the years focused more on social integration and how

social integration could in turn impact academic integration (e.g. (Braxton et al., 2000; Pascarella, Duby, & Iverson, 1983).

Social integration can be defined as student involvement in the social system of the university and includes both interactions with other students and with faculty members (Tinto 1975). Tinto originally thought of social integration as only occurring outside the classroom, namely in the form of extracurricular activities or attending office hours. However, this led to critiques about how this theory would be applicable to non-residential commuter campuses where students often only go to the campus to participate in class (Braxton et al., 2000; Pascarella et al., 1983). Thus, the idea of social integration began to include both interactions among students outside the class, as well as interactions between students and instructors in class and in office hours (Braxton et al., 2000; Severiens & Schmidt, 2009; Tinto, 1997). Tinto further proposed that participating in collaborative learning in the classroom (Tinto, 1997), which was called active learning in the model positioned by Braxton and colleagues in 2000, could help students socially integrate by developing relationships among students in class. This could mean that active learning compared to traditional lecture could lead to greater social integration and could be particularly important for commuter non-residential campuses with more non-traditional students. Further, scholars such as Braxton and colleagues, have argued that social integration is far more important than academic integration for student persistence in college (Braxton, Jones, Hirschy, & Hartley, 2008; Braxton et al., 2000).

ACTIVE LEARNING SCIENCE COURSES

Numerous national recommendations have called for the transformation of college science courses from traditional lecture to active learning (AAAS, 2011). Active

learning is defined as the opposite of passive transmission of information from instructor to student (Eddy, Converse, & Wenderoth, 2015; Freeman et al., 2014). Rather, students in active learning are constructing their own knowledge, often by interacting with the instructor and/or other students in the class. Students in active learning are often answering questions, testing their knowledge more frequently than traditional lecture courses. Active learning activities often include groups of students working together to solve problems, which is what has been proposed to lead to social integration (Braxton et al., 2000).

However, it is currently an assumption that collaborative learning in groups in active learning classrooms leads to social integration (Braxton et al., 2008, 2000). There are many different ways of implementing active learning and we do not know if certain active learning strategies are more beneficial for certain groups of students. Conversely, we do not know if certain active learning strategies are disadvantaging certain groups of students. When we ask students to work with each other in class, we may assume that everyone is participating equally and receiving the same benefits from interacting with each other. However, studies have shown that there are inequities in participation in groupwork with men preferring to take on leadership roles (Eddy, Brownell et al. 2015). Further, forcing students to participate, even if that leads to equitable participation, does not necessarily mean that the student will be comfortable in the group. If the interactions are not good in the group, then it is quite possible that these increased interactions may not lead to social integration. Rather, the impact of active learning on social integration could be neutral, or worse, could be negative for a student.

Given the increased number of interactions between students and instructors and among students in active learning, it has been proposed that student social identities are more relevant in active learning courses than in traditional lecture courses and could impact the experiences of students in active learning classes. Specifically, active learning may not necessarily lead to social integration, but how active learning is implemented, the relationships between the instructor and students, and the relationships among the students, all of which can be influenced by student social identities, can all impact the degree to which active learning leads to social integration, and ultimately persistence in college.

GOALS OF THE THESIS

The overarching theme of my thesis is identifying factors that could influence the student experience in college science classrooms, which could influence their social integration and ultimately, persistence in science. I have tackled this question by exploring two aspects of undergraduate science classrooms that could impact social integration: student interactions and student-instructor interactions. Additionally I have taken an equity approach to this research by exploring the impact of student social identities on their experiences in active learning science courses.

My thesis is comprised of five studies, each of which is either published or under review in peer-reviewed academic journals. I have used both qualitative and quantitative analyses to explore a suite of questions that all center on student experience in undergraduate science courses, particularly active learning courses. I am the lead author on all of the subsequent studies; I led all aspects of the research process, including

writing the manuscripts. Below I will describe each study and how it relates to my thesis as a whole.

Chapter 2 focuses on lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA) students in the context of active learning classrooms. Building directly on Tinto's theory of college student departure and examining how social identities can impact student social integration in the college classroom, I used an in-depth qualitative interview study design to examine how LGBTQIA students experience active learning classrooms compared to traditional classrooms. Students perceived that active learning classrooms made their identity more relevant and that aspects of how the active learning was implemented, specifically the characteristics of other students and instructors and the extent to which students were able to build a relationship with them, could be both negative and positive for their social integration. This in-depth exploratory study was the first to explore the experiences of LGBTQIA students in the context of a college science classroom, but beyond LGBTQIA identity, it revealed possible barriers for students with potentially stigmatized, minority identities in active learning classrooms.

Chapter 3 examines how student social identities can affect academic self-concept in an active learning class in a quantitative survey study. Academic self-concept is the perception of one's ability in a particular domain and is formed by comparing oneself to others. A consistent theme in several interview studies that I had done with students who had participated in active learning classroom, including the LGBTQIA study in Chapter 2, was that students were worried about sounding "stupid" when they shared their ideas in active learning classes and that other students were smarter. Academic self-concept is

a way to conceptualize students' perceptions of their ability in reference to other students. Although it has historically been assumed that increased interaction among students would lead to increased social integration, I hypothesized that if those interactions negatively impacted a student's academic self-concept, then it actually could lead to lower social integration. Using a survey and regression analyses, I tested the impact of social identities on student academic self-concept in the context of a large-enrollment active learning course in physiology. I found that, controlling for academic ability, gender and native English speaking were the two social identities that impacted academic self-concept, with females and non-native English speakers having lower academic self-concept compared to males and native English speakers, respectively. Lower academic self-concept could be a barrier for student persistence in science, so this study adds further evidence for the argument that increased interactions among students in active learning do not necessarily lead to increased social integration.

Chapter 4 explores how aspects of active learning courses could negatively or positively influence student anxiety. Using an in-depth qualitative interview study of 52 students, I examined how three common aspects of active learning – clickers, groupwork, and random/cold call – can influence student anxiety and their perceived learning in the course. All three of these aspects of active learning typically involve either interactions among students or between instructors and students. I found that both clickers and groupwork can be implemented in ways that students perceive increase or decrease anxiety, but that random/cold call is always perceived to increase anxiety. An important finding of this study was that student fear of negative evaluation – or the dread associated with the possibility of being negatively evaluated by others- is a prominent component of

interactions among students and between students and instructors that could affect social integration. This work was exploratory and intended to stimulate questions, which I will address in my discussion and future directions.

Chapter 5 is a mixed methods study on the impact of students perceiving that an instructor knows their name in a large-enrollment science course. I found that students appreciate when an instructor uses their name in a large-enrollment course and that they perceive that it helps build a relationship between the student and the instructor, which could increase social integration of these students. We explored whether social identities influence the extent to which a student perceives that an instructor knows their name and we found that gender gaps in this perception were ameliorated in a course that used name tents – a piece of cardstock displaying a student's name that they set in front of them during class. Further, students indicated that the use of name tents helped them build relationships not only with the instructor, but also with other students in the class. Thus, name tents could be a simple way to increase social integration in large-enrollment college science courses.

Chapter 6 is a quantitative study on the impact of instructor use of humor in the context of large-enrollment science courses. I conducted this study in the context of a biology education research course-based undergraduate research experience (CURE) with 16 students. I led the research team in this project and coordinated all aspects of the project. Instructor humor has been proposed as a positive way for instructors to build relationships with students, so we wanted to examine the influence of instructor humor on students' belonging in the class, attention to course content, and instructor relatability. Further, building on our prior work that illustrated gender differences in factors that could

influence social integration, we specifically examined how student gender could influence how students perceived instructor humor. In this CURE, we designed the research question, developed and validated a survey instrument, and collected data from over 1200 students enrolled in 25 different college science courses. Using qualitative coding methods and quantitative analyses, we found that although students greatly appreciate instructor use of humor, the type of humor mattered. Specifically, women were more offended by more topics and males thought that more topics were funny. Thus, what instructors choose to joke about could influence social integration, but the degree to which students are positively affected is influenced by gender.

Chapter 7 is the final chapter of my thesis and includes suggestions for future work based on some of the findings of my studies, specifically focusing on how student fear of negative evaluation may limit the extent to which students can socially integrate in active learning science courses.

CHAPTER 2

COMING OUT IN CLASS: CHALLENGES AND BENEFITS OF ACTIVE LEARNING IN A BIOLOGY CLASSROOM FOR LGBTQIA STUDENTS

ABSTRACT

As we transition our undergraduate biology classrooms from traditional lectures to active learning, the dynamics among students become more important. These dynamics can be influenced by student social identities. One social identity that has been unexamined in the context of undergraduate biology are lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA) identities. In this exploratory interview study, we probed the experiences and perceptions of seven students who identify as part of the LGBTQIA community. We found that students do not always experience the undergraduate biology classroom to be a welcoming or accepting place for their identity. In contrast to traditional lectures, active learning classes increase the relevance of their LGBTQIA identities due to the increased interactions among students during groupwork. Finally, working with other students in active learning classrooms can present challenges and opportunities for students considering their LGBTQIA identity. These findings indicate that these students' LGBTQIA identities are affecting their experience in the classroom and that there may be specific instructional practices that can mitigate some of the possible obstacles. We hope that this work can stimulate discussions about how to broadly make our active learning biology classes more inclusive of this specific population of students.

Individuals who identify as lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA[1], See Table 2.1 for a set of definitions relevant to this paper) make up an estimated 3.6% of the overall US population (Inc, n.d.). As a group, LGBTQIA individuals have been thought to be historically underrepresented in science, technology, engineering, and math (STEM), but few empirical studies have been done (Cech, 2015; Patridge, Barthelemy, & Rankin, 2014). We also know very little about the undergraduate STEM experience for individuals that identify along the LGBTQIA spectrum, making it difficult to pinpoint why LGBTQIA individuals are at risk for leaving STEM. Institutions rarely collect this demographic information from students and there are only a small number of studies that have explored this population in the context of STEM education (Cech & Waidzunas, 2011).

Table 2.1

Definitions of LGBTQIA-Related Terms

Term	Definition
Asexual	A term used to describe someone who does not experience emotional, physical, and/or sexual attraction
Being out	Not concealing one's sexual identity or gender identity
Bisexual	A term used to describe someone who is emotionally, physically, and/or sexually attracted to both men and women
Cis-gender	A term used to describe someone whose gender identity and biological sex assigned at birth align (e.g., identifies as female and female-assigned at birth)
Coming out	Voluntarily making one's sexual identity or gender identity known to others
Gay	A term used to describe individuals who are primarily emotionally, physically and/or sexually attracted to members of the same gender. This can be used to describe both men and women.
Gender fluid	A gender identity that describes someone whose gender identification and presentation shifts over time
Gender dysphoria	A condition where one feels discomfort or distress because their emotional and psychological gender identity is different from their biological sex assigned at birth
Gender normative	The assumption that individual gender identity aligns with societal expectations for what it means to be a girl/woman/female or boy/man/male

Gray-sexual or gray-asexual	A term that describes someone who identifies with the area between asexuality and sexuality. Some may prefer this term because they experience sexual attraction very rarely, only under specific circumstances, or of an intensity so low that it is ignorable
Heteronormativity	Norms and practices that assume binary alignment of biological sex, gender identity and gender roles and establish heterosexuality as a fundamental and natural norm
Heterosexism	The assumption that all people are or should be heterosexual. Heterosexism excludes the needs, concerns, and life experiences of lesbian, gay, bisexual and queer people while it gives advantages to heterosexual people. It is often a subtle form of oppression, which reinforces realities of silence and invisibility.
Heterosexual	A term that describes someone who is emotionally, physically, and/or sexually attracted to members of the opposite gender
Homosexual	An outdated term that describes a sexual orientation in which a person feels physically and emotionally attracted to people of the same gender
Intersex	Describes someone whose combination of chromosomes, gonads, hormones, internal sex organs and genitals differs from the two expected patters of male and female
Lesbian	A term used to describe women attracted emotionally, physically, or sexually to other women
Passing (gender identity)	Occurs when someone is recognized as the gender identity that they identify as (e.g. a trans-male being recognized by others as male)
Passing (sexual-orientation identity)	Occurs when someone of a minority identity is assumed to be a member of a majority identity (e.g. someone who identifies as gay is assumed to be straight)
Pansexual	Describes someone whose emotional, physical and/or sexual attraction is not limited by sex or gender identity
Queer	An umbrella term used to describe individuals who identify as non-straight. Also used to describe people who have a non-normative gender identity. It is important to note that some members of the community may find this term offensive, while others take pride in reclaiming it.
Straight privilege	A term used to describe societal privilege that benefits individuals who identify as (or are perceived to identify as) straight that are denied to members of the LGBTQIA community
Transgender	A term used to describe a person who lives as a member of a gender other than that expected based on anatomical sex designated at birth

Note. Language and labels are important for this community, especially because of historical stigmas associated with particular labels. It is important for members of the LGBTQIA communities to have choice over what term to use to describe their identity. Many of the terms below have multiple definitions. We chose to define each term in a way that most closely reflects the way in which it is used in this manuscript. The definitions for these terms were taken verbatim or slightly adapted from the following resources: Asexuality.org Definitions: http://www.asexuality.org/home/?q=general.html
LGBTQIA Resource Center Glossary : http://lgbtqia.ucdavis.edu/educated/glossary.html The Safe Zone Project Core Vocabulary 2.0: http://thesafezoneproject.com/activity/core-vocabulary/ UC Berkeley Gender Equity Resource Center Definitions of Terms: http://geneq.berkeley.edu/lgbt_resources_definiton_of_terms#heterosexual_privilege

LGBTQIA identity is a unique social identity for a number of reasons. First, it is often an invisible identity, meaning that people may need to "come out" to let others know that they identify that way (de Monteflores & Schultz, 1978; Perez, DeBord, &

Bieschke, 2000; Quinn, 2006). We live in a heteronormative and gender-normative society where the sexual orientation of people is typically assumed straight until told otherwise and gender is usually assumed to align with biological sex unless otherwise indicated (Bilimoria & Stewart, 2009; Braun & Clarke, 2009; Chrobot-Mason, Button, & DiClementi, 2001; Kitzinger, n.d.). Second, awareness and saliency of LGBTQIA identity changes over time and for some individuals, there is a degree of fluidity and rejection associated with their identity (Kinnish, Strassberg, & Turner, 2005; Morgan, 2013). Lesbian, gay, and bisexual identity development often occurs between ages 12 and 25, but each LGBTQIA individual has a unique timeline for becoming aware of and internally accepting their identity (Calzo, Antonucci, Mays, & Cochran, 2011; de Monteflores & Schultz, 1978; Rust, 1993). Finally, LGBTQIA is a social identity that is still stigmatized to some degree and can be a source of tension, particularly for individuals and their families with certain beliefs or religious identities (D'Augelli, Hershberger, & Pilkington, 1998; Etengoff & Daiute, 2014; Newman & Muzzonigro, 1993). As such, many members of the LGBTQIA community may feel as though they need to conceal their identity, at least in certain situations, and sometimes the decision to come out is associated with concern for losing straight privilege (Chrobot-Mason et al., 2001; Goffman, 1986; Orlov & Allen, 2014; Quinn, 2006).

Undergraduate classrooms are particularly relevant places to examine the experiences of LGBTQIA individuals because many individuals begin exploring their LGBTQIA identity during college (Vaccaro, 2006). To our knowledge, there are no studies of the experience of LGBTQIA students specifically in undergraduate classrooms. The limited research on the experiences of LGBTQIA students in college more generally

indicates that they have been subjected to overt homophobia, subtle discrimination, and feelings of isolation on some college campuses (Herek, 1988; P. Love, 1997; P. G. Love, 1998; J. S. McKinney, 2005; Rankin, 2003; Rhoads, 1994). These experiences can negatively affect the mental health of LGBTQIA students; for example, lesbian and bisexual college women are more likely to experience mental health issues such as anxiety, anger, depressive symptoms, self-injury, and suicidal attempts than their straight counterparts (Kerr, Santurri, & Peters, 2013). Although much has changed recently as far as public opinion and campus climate regarding this social identity (Dugan & Yurman, 2011), including the national legalization of marriage equality in 2015 (*Obergefell V Hodges*, 2015), there is still evidence that LGBTQIA individuals face discrimination and double standards compared to their straight counterparts (American Physical Society, 2016; Human Rights Campaign, n.d.; Mishel, 2016). For instance, LGBTQIA instructors perceive that they could lose their professional authority if they come out to students (Russ, Simonds, & Hunt, 2002). A 2014 survey of workplace climate, including faculty members, found that 70% of participants said that talking about gender identity or sexual orientation in the workplace was "unprofessional" (Human Rights Campaign, n.d.) and a term of "heteroprofessionalism" has been coined to describe how gay men are discouraged from expressing an identity that is seen as outside normal (Mizzi, 2013). The 2016 LGBT Climate in Physics Report, published by the American Physical Society, concluded that isolation was a common theme for many LGBT physicists. Even though coming out at work and working for an organization that was presumed to be more supportive of the LGBTQIA community was related to higher job satisfaction and lower job anxiety (Griffith & Hebl, 2002), there is still a prevalent view that LGBTQIA

identities are irrelevant to share in the workplace, especially the scientific workplace (Bilimoria & Stewart, 2009) and many scientists are not out to most of their colleagues (American Physical Society, 2016).

STEM disciplines are historically dominated by white straight cis-gender men (National Science Foundation/National Center for Science and Engineering, n.d.) and these disciplines in particular have been prone to a lack of tolerance and/or acceptance for the LGBTQIA community (American Physical Society, 2016; Bilimoria & Stewart, 2009; Cech, 2015; Cech & Waidzunas, 2011; Patridge et al., 2014). Unlike non-STEM disciplines, STEM disciplines are typically assumed to be objective and devoid of influence of social identities, which may be why STEM disciplines are generally less accepting of individuals sharing their LGBTQIA identities (Bilimoria & Stewart, 2009). LGBTQIA employees in STEM fields report more negative experiences due to their identity than LGBTQIA employees in non-STEM fields (Cech, 2015). Further, scientists who are out to their colleagues report pressure from their STEM colleagues to "tone down their 'gayness'" (American Physical Society, 2016; Bilimoria & Stewart, 2009). In the college context, LGBTQIA engineering students have to "navigate a chilly and heteronormative engineering climate by passing as heterosexual" and that issues of sexual orientation are usually considered irrelevant or inappropriate in the engineering environment (Cech & Waidzunas, 2011). Thus, STEM classrooms may be particularly challenging places for students who identify as LGBTQIA.

As we shift our STEM classrooms away from traditional lecturing towards active learning (Freeman et al., 2014), the classroom climate changes. In traditional lecture classes, students could come to class and invisibly listen to a lecture. In contrast, in

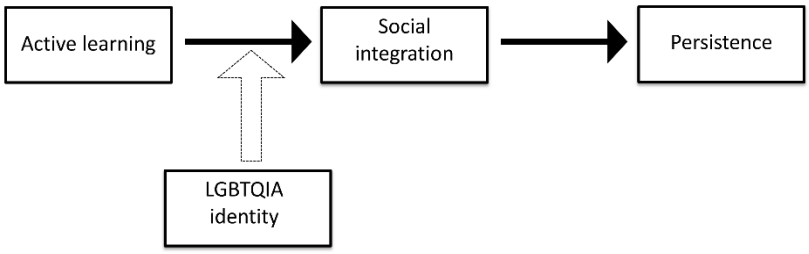
active learning classes, students are asked, and often required, to actively engage with other students and the instructor (Eddy, Brownell, Thummaphan, Lan, & Wenderoth, 2015; Eddy, Brownell, & Wenderoth, 2014). While active learning approaches have been shown to decrease achievement gaps among students of different social identities (Eddy & Hogan, 2014), the interaction among students in active learning can promote greater awareness of who other students are and may exacerbate feelings of isolation for students who have a minority social identity. Students who are in a minority status in the classroom may try to remain invisible or seek out opportunities to work with other students who are similar to them. In a recent study based in an introductory biology class, historically underrepresented racial minority students were shown to be more likely to prefer the role of listener in small groupwork compared to white students who preferred the role of leader (Eddy, Brownell, et al., 2015). Another recent study in an active learning introductory biology course showed that over the duration of a semester, Black students sought out other Black students to work with, even if that meant moving outside of the requested seating in the lecture hall (Freeman, Theobald, Crowe, & Wenderoth, 2017). These studies support the idea that, in contrast to traditional lecturing, active learning changes the dynamics of the classroom so that *who* the instructors and students are has a larger impact on the student experience, particularly for students who are in the minority. Given the small percentage of LGBTQIA students and the likely lower *perceived* percentage of LGBTQIA students since most students are not out to the whole classroom, we hypothesize that LGBTQIA students hold perceptions that they are in a minority status in most classrooms.

In this study, we set out to examine the experiences of LGBTQIA students in undergraduate biology classrooms, with specific interest in how active learning could influence that experience. In this manuscript, we use an adapted Tinto's theory of college student departure (Tinto, 1975), which focuses on social integration in an active learning classroom, as a lens to explore the unique experiences of LGBTQIA students. Tinto proposed that social integration, defined as student involvement in the social system of college (e.g. interactions with peers and faculty), is a key predictor of student persistence in college (Tinto, 1975, 1997a). He proposed that participating in collaborative learning groups in the classroom context, which was called active learning in the model by Braxton Milem and Sullivan (Braxton et al., 2000), enables students to develop a small community of supportive peers. Participating in active learning classroom activities may help students develop peer relationships that help them to integrate into the larger college community and ultimately, lead to increased persistence in college.

While Tinto recognized the potential for student social connections to emerge from collaborative learning activities, he did not explore the direct impact of students' social identities on the development of peer relationships stemming from these activities in the college classroom. As we transition our classrooms to be student-centered with more opportunities for students to engage with instructors and with each other, we suspect that students' social identities become more apparent and important as students form and strengthen social connections within the classroom. However, we must be mindful that while active learning may provide opportunities for social inclusion in the classroom, some students may feel more isolated if they perceive that their identities are not accepted or acknowledged. As such, in this study, we used an adapted Tinto's theory

of student departure that includes social identities as a key factor in the development of social integration through active learning (Figure 2.1). Using this lens, we explore the experiences of LGBTQIA individuals in undergraduate biology classrooms that adopt active learning teaching strategies. We hypothesize that their identities will influence how active learning leads to social integration.

Figure 2.1. A Hypothesized Influence of Social Identity on an Abridged Model of Tinto's Theory of College Student Departure



METHOD

INSTITUTIONAL AND CLASSROOM CONTEXT FOR RECRUITMENT

We recruited students from one upper-level undergraduate biology course at a large public research-intensive institution in the southwest. This course was co-taught by a male and a female instructor in an active learning way that relied on student groupwork in nearly every class session. Students were asked to complete assignments outside of class based on the readings to help them prepare for class. Class sessions of ~180 students were held two times per week in a large lecture hall with traditional seating. Roughly 70% of the lectures were spent on student-centered activities, which almost always involved group work. Individual instructor approaches to active learning varied, but often included clicker questions with peer discussion, students completing worksheets

in groups, and students comparing concept maps with each other. Students also met for one class session per week (called recitation) in a studio classroom for ~45-60 students with tables for six students each. Approximately 90% of the recitation sessions consisted of student centered activities, which always were structured around groupwork. In both the lecture and the recitation, students were usually able to choose whom they sat next to and worked with, although the instructional team typically prompted students who were sitting or working alone to join a group.

RECRUITMENT

An instructor of the course sent out an email to the whole class that invited students who identify as a member of the LGBTQIA community to participate in an interview about LGBTQIA student experiences in undergraduate biology courses in hopes of creating a more inclusive biology community. Students were informed that they would receive a gift card in return for participating.

Of the 181 students enrolled in the course, seven students responded with an interest to participate in the interviews. This 3.9% of the class aligns with the national estimate of 3.6% of the population identifying as part of the LGBTQIA community (Gates and Newport, 2015), making it likely that we recruited most students from this class who identify as LGBTQIA. While seven students is a small number, it is important to keep in mind that most studies on LGBTQIA students have small sample sizes given how difficult it can be to access this population. One of the strengths of our recruitment is that we had a diversity of LGBTQIA identities represented in our sample, including transgender and gender queer students who are rarely studied. Further, because we sampled from a single class that used active learning and groupwork extensively, we

were able to document both shared and unique experiences of LGBTQIA individuals in response to the same active learning environment. Finally, given the general paucity of information on the experience of LGBTQIA students in undergraduate biology classes, this exploratory qualitative study is an important first step in documenting their experiences and the opinions of these students is sufficient to begin to explore these questions.

DATA COLLECTION

We conducted two sets of semi-structured interviews, all of which were conducted by one interviewer (author KC). Each interview was audio-recorded, transcribed, and then coded for themes and subthemes by two reviewers (authors KC and SB) using a combination of content analysis and grounded theory (Glaser and Strauss, 1968). The semi-structured interview format allowed the interviewer to explore interesting topics that came up in conversation with different students. Therefore, a topic explored in-depth in an interview with one student may not come up in an interview with a different student. For this reason, the topics that make up a subtheme were not necessarily explored with each student. The three major themes presented in the results section were supported by data from interviews with all seven students unless otherwise noted. Student quotes were minimally edited for clarity and member checked (Patton, 1990). Data were anonymized and pseudonyms have been given to the students.

The first set of interview questions were intended to explore the students' LGBTQIA identities and how, if at all, their identities impacted their experiences and relationships in biology classes and the broader biology community. We conducted the interview in the middle of the term. We suspected that students had not previously been

asked about how their LGBTQIA identity might impact their experience in a classroom, so we decided to give students time to articulate their thoughts before the interview began. Immediately before the interview, we gave them a handout with specific priming questions. We gave them about five minutes to write down their thoughts and students were told that they could use the piece of paper as a reference during the interview. Students expressed that having time to think through the questions just before the interview was helpful because most had not been asked to discuss their identity in the context of the biology community. Some students referenced the handout when answering interview questions and all students elaborated on their responses in the interview itself. We used grounded theory to identify interesting themes that emerged from the initial interviews that we wanted to explore further. Differences in student experience between traditional lecture and active learning biology classes emerged from the data and informed a second set of interview questions.

In this second set of interviews, we used an adapted Tinto's theory of college student departure (Tinto, 1975, 1997a) as a lens to explore how, if at all, students' LGBTQIA identity impacted their active learning experiences and subsequent social ties to other students in the classroom. The second set of interviews were conducted with the intent to explore participant experiences as LGBTQIA students in active learning and traditional lecture biology courses. Questions were created to align with this theory. The second set of interviews were conducted within a month after the active learning course had ended to ensure that students felt that they could talk freely about their experience in the course without having to worry that it would impact their grade, but before they would forget details about their experience.

This study was done in accordance with an approved IRB.

QUALITATIVE APPROACH

We predicted that the ways in which LGBTQIA identities influence student experiences within an active learning classroom would be unique to each student's individual identity and the context of a particular setting. Therefore, we chose to explore our research questions using qualitative methodology, which calls to study people in the context of the situation they find themselves (Taylor, Bogdan, & DeVault, 2015). Recruiting and interviewing students from the same active learning biology class allowed us to minimize the variability of different settings, and focus on how different students experience the same phenomena (Morse, Barrett, Mayan, Olson, & Spiers, 2002). This is particularly important because there is not a single agreed upon definition of active learning (Eddy, Converse, et al., 2015; Freeman et al., 2014) and we were interested in exploring how students experience specific elements of an active learning classroom (e.g. groupwork in this particular active learning class). Limiting the population of this study to LGBTQIA students enrolled in the same upper division biology course maximized our chances of saturating the data by identifying recurring themes (Morse et al., 2002). This exploratory interview study is a first step in identifying key themes that we suspect may be shared by LGBTQIA students in other active learning classrooms, which would be of interest to explore in future studies.

RESULTS

LGBTQIA PARTICIPANTS

All of our interview participants had unique identities, backgrounds, and experiences. While we identified some interesting themes that emerged from the data,

we cannot make any generalizations about whether these perceptions or experiences are true of the larger LGBTQIA population. We want to emphasize that these students are not intended to be representative members of that particular identity along the LGBTQIA spectrum. Individuals have different levels of saliency of the identity for themselves, but also have different levels of being out to friends, family, and acquaintances. The identity itself, how important that identity is to the individual, and the degree to which the individual is out to others can all change over time. Thus, in this paper, we present the opinions and responses of seven students who identify in specific ways along the LGBTQIA spectrum at this particular point in time.

Further, even if two student responses represent a similar theme, it is highly likely that they have a nuanced experience in the classroom as it relates not only to their LGBTQIA identity but also to other social identities (e.g. race/ethnicity, gender, socioeconomic status). To capture these personalized experiences, we often included quotes from different students to illustrate findings throughout the manuscript. These findings are meant to be exploratory and thought-provoking, but future work needs to be done on this understudied population to delve into the intersectionality of students' other social identities.

Language is particularly important for members of the LGBTQIA community, including the label that individuals use to describe themselves. For example, a female who is interested in a same-gender partner may prefer the term lesbian or gay or queer and it may be important for her sense of identity that her preferred label is used. As much as possible, we tried to describe each participant's LGBTQIA identity both in and outside the classroom using their own language. We summarize these data in Table 2.2.

Table 2.2

Description of Interview Participants' Self-Described LGBTQIA Identities

Student	Self-described LGBTQIA identity	Description, timeline, and importance of identity to student (using the students' own words)
Sonja	lesbian	Sonja identifies as a lesbian and prefers the pronouns "she/her." She has known that she is a lesbian since she was young and feels that the identity is very important to her. She first came out in middle school and now considers herself to be very out. Some of her family and most of her friends know that she is out. She thinks that when people see her, some people think that she is a lesbian, but others do not.
Allan	gay	Allan identities as gay and prefers the pronouns "he/him." He considers his gay identity an integral part of who he is. He first came out in high school and is now out to his family and most of his close friends. Allan thinks that he typically passes as straight.
Josephine	gay	Josephine identities as gay and prefers the pronouns "she/her." Josephine does not feel that her gay identity is central to who she is, although she perceives that it changes the way she thinks. She first came out in high school to her family and a few friends and is now out to her close friends. She perceives that others recognize that she is gay.
Margaret	bisexual	Margaret identifies as bisexual and strongly identifies as female. She prefers the pronouns "she/her." Margaret's bisexual identity is important to her. She first knew that she was bisexual early in high school and came out soon after she realized her identity. She is out to her family and friends, but because of her specific identity (bisexual), she feels like an outsider in the LGBTQIA community. She perceives that she passes as straight.
Alex	transgender	Alex identifies as transgender (female to male) and prefers the pronouns "he/him." He has transitioned very recently and his physical appearance/voice changed significantly over this term. He first started identifying as lesbian as a sophomore in high school before he learned more about the transgender community and started to identify as transgender. He explains that he has always kind of

		known that being transgender is his identity, but only within the past year and a half did he begin to identify as transgender. The identity is very important to him and he is 100% out.
Mar	queer	Mar describes their primary identity as queer. They identify as trans-masculine, but also genderfluid and prefers the pronouns "they, them, their." Mar describes feeling lost with who they were prior to discovering their identity within the past year. This identity is pretty important to them and has allowed them to establish important friendships. In the middle of the term, just prior to the first interview, Mar changed their name from "Kelcie" to "Mar" and felt as if they were coming out more.
Florence	asexual	Florence identifies as asexual and prefers the pronouns "she/her." Being asexual is really important to Florence, especially because she feels that most people do not know of or understand the identity. She has felt asexual her whole life, but she discovered the word to describe her identity about a year ago. She also uses the term gray-sexual to describe her sexuality because she is not 100% asexual. At the time of the first interview she was only out to five people, however, at the time of the second interview she described being out to more people, including her family.

Throughout the manuscript, we refer to these students as members of the LGBTQIA community. Although there are differences in the experience of individuals of a specific identity (e.g. gay versus bisexual versus asexual) that we lose by aggregating them into one group, there is some evidence that the experiences among gay, lesbian, and bisexual students are more similar than they are different in college environments (Dugan & Yurman, 2011). However, gender identity is fundamentally different than sexual identity, so it is likely that transgender students have distinct experiences and there is limited data on how the experiences of transgender students compare with gay students. What is similar among all of these students is that they are managing their identities in a

classroom culture that is currently heteronormative and gender normative and historically homophobic and heterosexist (Perez et al., 2000).

THEME #1: LGBTQIA STUDENTS DO NOT PERCEIVE OVERT DISCRIMINTATION, BUT THEY DO NOT PERCEIVE THE BIOLOGY CLASSROOM COMMUNITY BROADLY AS A WELCOMING OR ACCEPTING SPACE FOR THEIR IDENTITIY

We probed broadly about whether students who identified along the LGBTQIA spectrum felt as though they were comfortable in undergraduate biology classrooms. Overall, we found that LGBTQIA students do not perceive the biology classroom to be accepting of their identity. We present several sub-themes that emerged below.

LGBTQIA students feel that it is no longer socially acceptable to be overtly homophobic, however students still experience subtle forms of homophobia in the biology classroom. All participants stated that they felt as though it was not socially acceptable to be openly homophobic, although some of them mentioned that it was still acceptable to be transphobic.

> Josephine (gay): It's very unpopular to be homophobic. Like that does not fly.
>
> Margaret (bisexual): I've talked to people who are like "I'm not homophobic, like it's cool if you're gay, straight, or bisexual, but why do people have to change their sex? That's what you were born as, that's who you are."

The two students who identified as trans-masculine/queer and transgender indicated a higher level of concern than the other students for overt discrimination in the classroom setting. This may be due to having a more visible identity and/or it may be

due to less general acceptance of transgender people in society (E. Lombardi, 2009; E. L. Lombardi, Wilchins, Priesing, & Malouf, 2001).

> Alex (trans): I thought about telling my groupmate about being trans but this is when Caitlyn Jenner started getting big and he was just like "I don't understand [transgender people], it doesn't make sense to me." And I was like "ehhh, all right. I don't want to put that out there; I just want to finish the semester." There's still a lot of close-minded people out there who don't really accept the idea and they're very transphobic.

> Mar (queer): In society today, there's a lot of violence about trans people, so it's really scary to talk to people about being trans if you don't know what their take on it is.

Despite not perceiving overt homophobia, all but one of these LGBTQIA students indicated that at some level, they perceived the undergraduate biology classroom to not always be a welcoming or accepting environment for their identity, although this was often perceived as being subtle and/or embedded in other beliefs.

> Allan (gay): I feel like a lot of the times I've heard homophobia from students hidden behind the fact that they're not trying to seem homophobic. I think that's the new thing now- it's not acceptable to be homophobic- but people still are, so they do show their prejudice in different ways.

> Margaret (bisexual): I feel like we've come a long way where people can't be saying something racist, but religion and people's beliefs still mask homophobia.

Sharing one's LGBTQIA identity with the biology community is perceived to be inappropriate. Several students discussed how sharing one's LGBTQIA identity was inappropriate information to bring up in a science community, which echo findings from other studies focused on STEM environments (Bilimoria and Stewart, 2009; Cech and Waidzunas, 2011). Margaret had a specific example of when someone told her that it was inappropriate to share her identity as someone who is bisexual. On a biology class discussion board, a student posted a comment that was negative towards transgender people, so she felt the need to come out about her own identity on the discussion board.

> Margaret (bisexual): So I mentioned that I was bisexual to merely sort of show that this matters to me because I feel like I'm part of this community and he was like 'we don't need to know your dirty secrets, we don't need to know your personal life and I don't go around flaunting who I have sex with' and it was really- it was really- that was the first time I was like 'Really? I can't even mention this?' And I think it's upsetting that the default is heterosexual and people just assume that's what's normal. He even said something like, I don't think he used the word abnormal, but he said like atypical, like 'don't pretend- most people are this and you fall outside. We don't need to know about people who fall outside of the norms.

In another example of how students did not perceive undergraduate biology classes to be accepting of their identity, Josephine reflected concern over whether she could share her LGBTQIA identity with an instructor. This internal struggle was reflected in her worry about whether coming out to an instructor

would be considered unprofessional, even though she recognized this as a double standard that was not true for straight students.

Interviewer: Talk to me about the potential benefits you see, if any, of being out to instructors in an active learning classroom.

Josephine (gay): Coming out to instructors feels like mixing personal and professional. Yeah it feels like it's too easy to extend into the too personal category. I don't think my professors want to care about my personal life and I don't think they should. I don't know if I could share that. I don't know. There's something about that that's like- there's something about me that's deeply uncomfortable with coming out to instructors.

Interviewer: If you were straight, do you think you would feel deeply uncomfortable for them knowing that about you?

Josephine (gay): No, and it's hypocritical and I recognize that it's hypocritical. It's very frustrating. See like I'm stuck. I don't want to tell anybody that I'm gay, but I want to know things that I should know as far as professional consequences for being gay and I just feel like those two things don't work together.

Josephine highlights this paradox between wanting to talk to people about how to navigate her identity in a professional setting and not feeling as though she can share her identity with faculty members. She feels as though this identity is "too personal" to share, even though this identity is an important component of who she is. Further, this student mentioned that she perceived "professional consequences" associated with being gay, indicating that she thinks being gay comes at a cost for her career in the broader

biology community. She went on to elaborate on her worry of the potential backlash of being gay as a biology instructor.

> Josephine (gay): But then if you're a junior faculty member, or if you're like an instructor rather than tenure-track faculty, then there could be repercussions for coming out. I don't know if people who work in supervisory roles or serve on committees decide on these things, but maybe you could offend somebody there. Or you could offend a student - which I think is a lot more likely. I wouldn't want to be putting myself in the position where a student could complain about me any more than I'm sure the students already complain about me.

Most of the students expressed some level of internal conflict about whether or not to express their identity in the biology classroom, although many of the students had difficulty describing their internal conflict or explaining why it exists (McCarn & Fassinger, 1996). Interestingly, they illustrated concern for how other students would react to them coming out, but could not seem to connect that concern back to why they were hesitant about coming out. Even though they all expressed that being a member of the LGBTQIA community is an important part of their identity, some worried about their identity not being taken seriously by others, that they could lose social and academic status, or be negatively judged for identifying as LGBTQIA.

> Allan (gay): The risks I usually see are they view me as less of a person or they view me as not even their equal, not intelligent, not their intellectual equal, and they don't want to work on projects or anything with me by virtue of being gay.

> Margaret (bisexual): I don't feel like people who are bisexual are taken as seriously. And I feel like in the professional world, people might see someone

who is gay and be like ‘well, they’re gay, you know they’re born that way or whatever, they can’t help it.’ But bisexual is seen almost like ‘you’re still playing around, you’re still messing around, figure it out.’ That’s how I feel. And bisexuals are seen as you’re really into sex. Like gay people can fall in love, and straight people can fall in love, but if you’re bisexual, you’re just having fun. I feel like that’s maybe the way people see it.

Florence (asexual): If I did bring up that I’m asexual, I don't know if [other students] are going to be mean about it, or accept it, or be a little leery but ask questions and still be accepting.

Mar (queer): The risks of coming out to other students include being judged, being disliked, maybe discriminated against.

Another student, Josephine, expressed concern that if she came out, it would be perceived by others as making a big deal about her sexuality or her having a specific agenda related to her sexuality, even though she just thought of it as something personal.

Josephine (gay): You never know what someone is going to think. You never know what beliefs other people have and there are certain people who are just like ‘that’s wrong.’ I don't want to be making a statement and I feel like it can be viewed that way, by coming out you’re making a statement, but I’m not trying to make a statement, I’m actively avoiding trying to make a statement.

Students report that they would feel more comfortable in an active learning classroom where they knew the instructor identified as LGTBQIA, but they worried about the negative impact of coming out on the instructor or other students. We asked students if they would feel more comfortable in an active learning classroom where

the instructor openly identified as a member of the LGBTQIA community. Six of the seven students said that they would feel significantly more comfortable in a classroom where they knew that an instructor identified LGBTQIA. All students mentioned that knowing an instructor was a member of the LGBTQIA community would positively affect them because they would know they have something in common with the instructor. This seemed to be particularly important for the students who identified as queer and asexual because they felt as though it was uncommon for them to encounter others with similar identities, especially instructors.

> Florence (asexual): I think I would feel more comfortable in a class if an instructor identified as asexual because it would be nice to know that somebody feels the same way I do, which right now, would be very rare. I've never been able to talk to somebody who feels the same way I do. Like ever. So it would be nice to talk to somebody that feels the same way I do about people.
>
> Mar (queer): I think would feel more comfortable in a class where an instructor identified as queer because I can relate to them on a different level. Not just on a student/teacher level. I think that if I think a professor might be queer and I see them as a queer person, then I can also see them seeing me as a queer person. Not just visually seeing but seeing as that more underlying 'I see you' sense of the word.

Despite the majority of students agreeing that they would feel more comfortable in a class if they knew their instructor identified as part of the LGBTQIA community, these LGBTQIA students still appeared to be apprehensive about instructors coming out to the entire class. They were concerned about how an instructor coming out would

affect other students and how it might negatively impact the instructor. However, they recognized a double standard that straight professors talk about their spouses and children freely and they never perceive a problem with straight professors talking about their families. This is evidence that these students perceive biology classrooms broadly to be unaccepting of LGBTQIA identities, even for the person with the most authority in the classroom.

> Josephine (gay): That's their personal life. You know what I mean? I don't feel like gay professors are obligated to say anything. I feel like a gay professor coming out to students could in a lot of situations just be kind of weird. Although when I think about it, I know a ton of my straight professors who are married or they have children.
>
> Allan (gay): That's a big move especially in a lecture style class with everybody who talks in biology like 'oh don't take them, they're a homosexual or they're gay or they're lesbian' because I can see my peers doing that too.
>
> Margaret (bisexual): You hear a lot of straight people talking about 'my wife or my husband' and I think if a gay male faculty member said 'oh my boyfriend' or something and people would be like 'whoa did he just say that?' And it doesn't happen. I've never had it happen before.

However, Sonja, who identifies as lesbian, has a different perspective than the other students. She did not demonstrate any conscious worry about how welcoming the instructor or other students in the biology class would be towards her identity. She indicated that she did not like it when people questioned her identity or doubted if she was a lesbian and acknowledged that discussing LGBTQIA issues could make people

upset, but that it did not impact how she felt about her own identity, nor did she feel it affect her experience in the classroom. At least outwardly in the interview, she did not exhibit signs of worry about what others thought of her identity. This is demonstrated in an example she gave of when she came out to another student in class:

> Sonja (lesbian): I don't think I cared if they were going to be accepting or not to be honest. My group member was really nice about it, she even told me it's fine and I was like "thank you I appreciate that, but I honestly don't think that you being OK with that or not is going to change who I am."

However, this is in contrast to the other students whose statements indicated that they broadly did not perceive the classroom to be a welcoming place for individuals, either for students or instructors, to express their LGBTQIA identities.

THEME #2: ACTIVE LEARNING CLASSROOMS INCREASE INTERACTIONS AMONG STUDNETS AS WELL AS BETWEEN STUDENTS AND INSTRUCTORS, INCREASING THE RELEVANCE OF LGBTQIA SOCIAL IDENTITIES IN THE CLASSROOM

All seven students indicated in some sense that they were more aware of their LGBTQIA identities in active learning classrooms than traditional lecture classrooms. They perceived that in traditional lecture classrooms, students do not need to interact with other students and instructors, so an individual student's social identities are less relevant. Several of the students indicated that they could be invisible in traditional lecture classrooms. However, in active learning classrooms, students are requested, if not required, to work with other students, which seems to heighten students' awareness of their own identities.

Allan (gay): In a lecture there's not as much time to talk about personal stuff. You're mostly sitting there taking notes. That's all we're expected to do in a traditional learning class, so it doesn't matter if I know their sexual orientation or political orientation or anything like that.

Josephine (gay): I'd sit by whoever in a traditional lecture, I don't care. I don't feel the need to be out in a traditional learning classroom. I don't think there's a lot of benefit there. Like in a traditional lecture in biochemistry, I was totally comfortable going there, nobody knew who I was, nobody knew the first thing about me, and that was fine. Totally comfortable. But in an active learning classroom, you have to interact with somebody. There's not the same safety net of just kind of withdrawing.

Florence (asexual): Yeah, I usually won't focus as much on how I choose my seat in a traditional lecture because I know I'm not going to talk to that person ever even though they're sitting right next to me.

Sonja (lesbian): In an active learning class, talking to each other is encouraged as opposed to a traditional lecture, you could just sit and not talk to the person next to you. It's important because if you're doing active learning and you need to work with the people around you, you need to be comfortable with them or else you're not going to contribute. You need, I guess, a comfortable environment to do so.

Mar (queer): In a traditional lecture class, coming out to other students is a choice that I wouldn't feel pressured at all to make. I think in an active learning classroom, I might feel a little bit of pressure- if I felt like it would make my

communication with someone better in an active learning classroom - then there might be a bit of pressure to come out. In the traditional learning classroom, if there was pressure to come out, it would be only based on my relationship with that person versus the environment of the classroom in an active learning classroom.

Alex (trans): In a traditional lecture class, I normally just pick a seat not close to people and mind my business. I don't think about being transgender because it's a 'get in, get out' kind of thing. I mean sit and pay attention for as long as you can. When I sit down in a traditional class, I just kind of sit there and pull out my notebook and kind of do my own thing, I don't really talk to the other people around me. I don't just look at them and go "Hey I'm Alex and I'm transgender." So I would only probably come out to the people in the active learning one. In this active learning class, first day I just said to my group "Hi I'm Alex, I'm transgender, please call me he even though I look like a she."

Sonja indicated that this active learning class was the first college class where she came out to the people around her. Although she had difficulty articulating why she came out to the people who sat next to her, she indicated that it had something to do with the interaction among students in an active learning class.

Sonja (lesbian): This is the first class that I have come out in, like to the people around me. I don't know why. I don't know why, I can't answer that. Maybe it's just the fact that I talk to them. It's only the people around me that know. In other classes, I don't think it's necessarily that I feel closeted because if they were

to ask me I'd be like 'yeah.' But the need for me to express my identity hasn't been needed.

Increased interaction with other students in an active learning classroom increases the opportunity for students to be identified due to their LGBTQIA identity. Due to the increased number of interactions among students in active learning, these students have to juggle learning biology content and deciding whether or not to either come out or to assert their LGBTQIA identity. Often discussions about biology content in small groups extends to more personal discussions in active learning classrooms, which may lead to questions that put LGBTQIA students in the tenuous position of being forced to come out about their sexual orientation, change the topic, or lie.

Allan (gay): Almost 90% of the time we discuss the biology problem and move onto something personal like where did you go to high school? What's your major? And I always actively think that's going to build into the questions that I don't want to talk about.

Josephine (gay): So basically in these active learning classrooms, socialization is normal, it's so integrated with the way the learning is done. You have a lot more of the social interactions and in any particular interaction- and you have a lot more casual interactions. Like in traditional classes, some people go with their friends and stuff, but a lot of people just show up and sit there. But before and after an active learning class, I feel like a lot more people talk with people around them and I feel like that is because you form closer connections because you talk because you're required to. And then there can be these

moments where you are basically confronted with a statement or a question that either is implying or questioning some sort of sexuality or gender construct that maybe doesn't apply to you or you disagree with. And then you have to make a decision like 'what am I going to say?

The students who believed that others perceive them as straight expressed that there is often an assumption that all students are straight, which means they have to come out in order to have their identity expressed. LGBTQIA students have to make the decision to share this information with people in a class and sometimes there is not a good opportunity to talk about it, even if they want to share it.

Margaret (bisexual): Being bisexual in a way that people look at me and they have no idea, they're not going to jump to any conclusions. But then, I don't know, it's just awkward to be like "Oh by the way, I'm bisexual."

Allan (gay): I feel like as a white male, I'm very straight passing in general and I don't sound gay either. So I feel like I blend in more, because it's not directly out there and I don't feel like people would be judging me because to them I'm straight. Coming out for me is active, like I have to say it.

Florence, who identifies as asexual, indicated that she felt more of a need for her to be out to active learning classrooms than traditional lectures because of the higher degree of interaction with other students.

Interviewer: Talk to me about any potential benefits you see, if any, of being out to other students in an active learning classroom.

Florence (asexual): People won't randomly flirt with me and they won't think if they're nice to me, then something is going to happen. That's happened

way too many times. 'I'm going to be nice to you, you should do something with me' and I'm like 'that's weird' because I think of niceness as niceness but apparently niceness is flirting. Usually if they do the flirting and the hinting and I'll casually be like 'hey I don't really like people' and they'll be like 'oh' and I'll be like 'yeah, let's go back to this work now.

Interviewer: Do you think those benefits are different for you in a traditional lecture?

Florence (asexual): I feel like in a traditional lecture they just probably wouldn't care. Usually I don't talk to anybody.

Interviewer: So why do you think there are more opportunities for that in an active learning classroom?

Florence (asexual): Because I think you get to know people better, and you talk to them more. Yeah, that's it. You get to know them more.

Allan, who identifies as gay, indicated that for him, the advantage of being out in an active learning class is that it could enhance the quality of the active learning exercise, so he felt some motivation to come out in order to have a better academic experience.

Allan (gay): The only benefit I can think of being out is working with [other students] regularly, it builds stronger friendships, it makes me feel closer to people, being out does make me feel closer to people. I feel like that leads to me having stronger debates or have more in depth conversations past 'I think A is the answer and I think A is the answer too,' in the classroom. I think friendships are important in the classroom to facilitate active learning. In a traditional lecture course, you don't necessarily have to be friends with the people that you sit

around and I feel like in active learning it helps improve the experience 100x if you're friends with the people around you.

Increased interaction with other students and instructors in an active learning classroom increases the opportunity for transgender or queer students to be misidentified. Other students who wanted to pass as their preferred gender felt as though there was greater pressure in active learning classrooms to come out because there were more opportunities for misidentification.

> Alex (trans): I felt that it was very necessary for me to come out at the beginning of the semester because there was a certain way that I wanted to be perceived and I didn't want to give people the opportunity to think otherwise.

However, Alex indicated that during groupwork in both active learning lectures and recitation sessions, his group members consistently used incorrect pronouns, misgendering him, and he had to consciously decide whether to correct them and further, reflect on why he had not been able to change his voice or physical appearance enough to pass as male.

> Alex (trans): I hate correcting people personally. So like if they say she, I won't really say anything because I feel like it's rude. I don't like calling people out and potentially making them feel bad even though I feel kind of dumb, like they still see me in a certain way and that's how they call me out, kind of, but I don't want to try to fix it so I just feel silly that they still see me that way.

Although misidentification of a student's identity can happen in either a traditional lecture class or an active learning class, there is often also increased interaction between the instructor and students in an active learning classroom. While at times this may

provide students with additional opportunities to explain their identity to the instructor, it also increases the possibility of accidental misidentification. Specifically, Alex had a problem with instructors who misidentified him when they called on students in whole-class discussions. For example, Alex had an instructor who repeatedly would use the wrong pronouns, but then would catch the mistake and correct it in front of the whole class. Not only did this bring attention to the student's identity, but it made the student feel uncomfortable about being misidentified in front of the class:

> Alex (trans): It's awkward. I don't know if embarrassing is the right word, but it's just kind of weird to be called both genders at the same time like "oh yeah she, I mean oh wait, he" and in my head, I was like "ahhhhh, so frustrating!" After class, the instructor would be like 'I'm so sorry about this by the way' and I like 'oh it's OK." I think being transgender you have to be open minded about the people learning about transgender.

While this student was trying to be patient with the instructor and saw this as an opportunity to help teach people about being transgender, the instructor misgendering him caused this student to become more aware of his transitioning status during class. Alex explained that in traditional lecture classes he did not usually participate in whole class discussions, but because he knew the students and instructors in active learning classes he was more likely to speak out in class discussions. However, he also indicated that simultaneously, he was self-conscious of participating in front of the whole class because he was concerned about how others would perceive him as far as his gender.

> Alex (trans): Sometimes because through the whole transition, your voice changing, it's gotten a little bit deeper, so I wonder if the person is going to

assume that I'm a dude or people are going to be like 'Hey look at that chick over there.' The constant thing that I think about is how people are perceiving me. So when I talk in front of class - I'm talking out in front of those lecture and all those people are seeing me because I'm talking- and I'm wondering if they're perceiving me the way that I want to or they're seeing me as female.

Student concern regarding gender identity may increase cognitive load in active learning classrooms. Alex's concern for how other students may perceive him also implies that he is spending class time thinking about his gender identity, increasing his cognitive load (Quinn, 2006). The effort required in maintaining an identity at the same time as learning biology means that these students are having to juggle multiple thoughts in their working memory (Sweller, 1988). Students who do not worry about how students perceive their gender do not have to occupy mental capacity in navigating these issues and instead can focus more on the academic content. Moreover, this misidentification and heightened cognitive load is less likely to happen in a class where there are fewer interactions between the instructor and students. For example, Mar explains that in active learning courses with significant student discussion, they are especially aware of how other students perceive them, which prevents them from focusing on the material in class.

Mar (queer): Even though I present in a way that makes me feel comfortable, my social anxiety unfortunately makes me take into account how other people see me. In discussion based courses I think it's rougher for my emotional state when I feel like I need to talk to people but I feel uncomfortable doing that because I don't know what their perception of me is, which is something I put a lot of value in. I

worry ‘Do they like me? Do they think that I’m stupid? Am I trying too hard to let them know that I’m queer? Is that something that they’re going to think is ridiculous? Are they one of those people that wants to know?’ and ‘Do I want those people to know?’ It’s just so much pressure on talking to people and I think it takes away from what I get from a course if I’m focused on people’s perception of me versus what I’m actually supposed to be focusing on in the class. In classes that aren’t so discussion based it’s easier for me to focus on the material.

Active learning classrooms are typically regarded to have more frequent assignments than traditional lecture classrooms. Whereas a traditional classroom may only have exams, most active learning classrooms have weekly if not daily assignments. Often, students have to complete assignments outside of class to demonstrate that they did the required reading. Additionally, some active learning classrooms, including the one that we recruited from, frequently use worksheets in the class that students put their name on. For students who are in the early stages of transitioning and/or have not yet legally changed their name, this means that almost on a daily basis, they have to use a name that they do not identify with in order to use email, course management sites (e.g. Blackboard), and to complete assignments. Consequently, these students are not fully able to express their gender identity in the classroom when they are required to write their legal name.

Alex (trans): I had to write my full legal name on my homework because I was terrified that it wasn’t going to get entered because the instructors would put my preferred male name in and be like “That name doesn’t exist in this class.”

Mar, who identities as queer, transitioned names during that semester, so they began the class as "Kelcie" and then half-way through the term, they identified as "Mar." This student indicated that at the end of the term, they felt no connection at all with their former name. The instructors were aware of this student's transition, so they informed the student that they could use the preferred name on assignments. This seemed to have a positive impact on the student. Mar stated that if they had been required to use the old name, then that could have been a reason not to come to class. Mar's comment highlights this internal conflict that LGBTQIA students may experience between needing to follow the rules of school to be successful in the course and being comfortable with their identity, which for this student was dependent on using a name that is representative of their identity.

> Mar (queer): I wrote my name a lot more in an active learning class because we had all of those worksheets. I used my legal name on exams because I didn't want my grade to get screwed up, but the instructors had told me I could use my new name on the homework and the worksheet and stuff and I started doing that. That made me feel pretty good. I don't even associate with that old name and that happened pretty quickly after I changed it so it was weird to be using that old name.
>
> Interviewer: Thinking about going through a name change in an active learning class and if you had to write your old name all the time, how would that impact you?

Mar (queer): That would definitely impact how comfortable I felt in a classroom and I don't know if it would impact me majorly as far as if I were to go to class or decide to not go to class, but I think it would play into that.

Active learning classrooms may provide additional opportunities for students to come out and find similar others. Although active learning presents a number of challenges for LGBTQIA students in terms of a greater emphasis on their identity, there are also some positive opportunities associated with active learning compared to traditional lectures. For example, active learning classrooms may provide LGBTQIA students with a larger number of opportunities to come out and find people who share similar identities. In the class where these students were recruited from, everyone was asked at the beginning of the term to write their preferred name on a name tent. They were asked to bring the name tent and display it during each class. Alex decided to write his preferred pronouns on the name tent to help people around him know which pronouns he preferred. This was how the instructors of the course became aware of him being transgender, so they started using his preferred pronouns. It eliminated the need for a student-initiated conversation about gender with his instructors.

Alex (trans): I had the idea of writing 'he, him, his' on my name tent at the beginning of the semester so hopefully people would use it. There were a lot of people who still kind of didn't, but there are people, like the instructors, who were able to pick up on it.

The increased interaction with other students in the class also gave LGBTQIA students the opportunity to teach them more about their identities and for LGBTQIA students to meet other LGBTQIA students.

Alex (trans): Coming out to other students in an active learning classroom gives [other students] the opportunity to learn more about how I identify. I wouldn't have met two other LGBTQIA people if I wouldn't have introduced myself the way that I did and then they wouldn't have someone they could relate to also. I feel like since I was able to come out and introduce myself that way, another student was able to make a connection and I was able to give him resources like there's a group that meets every other week downtown and trans guys and trans women get to meet up and talk about stuff like that. In an active learning classroom, I feel like I get to reach out to other people who don't have that opportunity to be open about it.

Margaret (bisexual): Maybe someone could benefit from sitting with somebody who is gay because they could talk to this gay person and the gay person could be really, really cool and blow their perception of gay people.

In fact, it has been shown that individuals who have more contact with LGBTQIA individuals in college tend to have more positive attitudes in general towards members of the LGBTQIA community (Liang & Alimo, 2005). Thus, active learning classrooms where students feel comfortable enough to come out could have positive implications for the LGBTQIA community that extend beyond the classroom.

THEME #3: GROUPWORK IN ACTIVE LEARNING CLASSROOMS PRESENTS SITUATIONS FOR LGBTQIA STUDENTS TO BE UNCOMFORTABLE

How comfortable a student feels is influenced by their own social identity and the social identities of others around them, particularly in their small groups (Eddy,

Brownell, et al., 2015a). We found that nearly all of our students were mindful about who they sat next to because they wanted to work with someone who would be accepting of their identity.

LGBTQIA students tend to be mindful about who they collaborate with during groupwork because they prefer to work with others who are accepting of their identity. Students indicated that at times they used past experiences with students who have specific social identities as a metric for how accepting members of those social identities would be towards them now. In short, they stereotyped people based on some characteristic that they associated with not being accepting of their LGBTQIA identity. Students admitted that they felt somewhat uncomfortable profiling people's acceptance based on their membership in another social identity, but that it was a way to try to quickly find people who would be more likely to accept their identity. Specifically, some students mentioned that they avoided anyone who looked as though they were members of a fraternity or sorority because they perceived that they would be less accepting of their LGBTQIA identity. Often they used membership in a fraternity or sorority as a way to categorize individuals who were hyper-masculine or hyper-feminine, characteristics of individuals who have been shown to harbor more intolerance for LGBTQIA individuals (Caballero, 2013; Worthen, 2014).

> Allan (gay): In a quick cost-benefit analysis, I usually avoid people who are wearing fraternity clothing. I have existing prejudices against straight guys mostly from high school and I guess I just carried it over. I just shy away from them in the first point because where I do see prejudice towards me it usually comes from that specific group of people. So I shy away from them because I'm

more comfortable working with females or other gay students. And if I can find another gay student that's fantastic but that's hard so it tends to be female students.

Margaret (bisexual): I mean if I see really super prissy sorority girl - I think a girl like that would be like "oh my god she's trying to hit on me" - I feel like maybe she would freak out or something.

Students also said that they used political or religious cues as indicators for whether someone would be accepting of their LGBTQIA identity. Again, they stated that they knew that many religious people and conservative people were accepting of their identity, but they felt that given the costs associated with not being accepted for their LGBTQIA identity, they wanted to play it safe. As a result, they usually tried to avoid students who they knew were religious or politically conservative based on their past experiences with the person. They also tended to not sit next to students who wore visible crosses or religious shirts. These students' assumptions that individuals who are religious or politically conservative are less likely to be accepting of LGBTQIA individuals are supported by the literature (Holland, Matthews, & Schott, 2013; Hooghe, Claes, Harell, Quintelier, & Dejaeghere, 2010; Nagoshi et al., 2008).

Interviewer: Do you wonder whether the person you're working with would be accepting of your gay identity?

Josephine (gay): Yeah, sometimes. I wonder about these people who are very religious because traditionally they do not accept and that's the main thing I

can think of or maybe if someone was wearing Donald Trump 2016, I would question.

Allan (gay): I look for crosses but then again that doesn't necessarily mean they're super religious but I have the tricks. I look for maybe religious clothing, and I don't try to judge religious clothing, whether it's Christian or Muslim or anything, but I just try to avoid those people.

Florence, who identifies as asexual, would try to avoid sitting next to anyone who seemed romantically interested in her.

Florence (asexual): Actually if someone is looking at me weird I'm probably not going to sit next to them. And by weird I mean really looking at me, like up and down kind of thing, like I'm giving myself too much credit, but in a sexual way. I'm just like maybe not, that might be a bad idea, that might get weird. It DOES get weird and then I have to tell them I don't really like people and they're like "really?" and I'm like "yeah I really don't like people."

Coming into the class and finding a seat is not simple for these LGBTQIA students. Their responses indicate the need to navigate social, political, and religious boundaries to find people who would be most accepting of their identity. All of the students were very careful to indicate that they knew people in all of these demographic groups who were accepting of their identity and that they did not mean to classify any demographic group as anti-LGBTQIA. However, due to a combination of their own personal experiences and broader societal influences, they perceived that these demographic groups displayed a higher degree of intolerance towards them and they wanted to avoid this possible lack of acceptance for their LGBTQIA identity.

Contrary to the other students, Sonja expressed that she not think about whether other students would be accepting of her identity when choosing a seat in class or interacting with her classmates. Sonja (lesbian): "I think if I were to sit next to someone who was not accepting of my identity, I wouldn't care."

Assigned groups and changing groups presents additional challenges for LGBTQIA students. In active learning classrooms, assigned groups and changing groups during the term presented challenges for many of these LGBTQIA students. They had to "test the waters" with new group members to get a sense for their acceptance and again, sometimes used religious and political identities as proxies for being accepting of LGBTQIA students. For students who felt as though they had a choice in whether to come out, they tried to establish whether the person would be accepting of their identity before making the decision to come out to them.

> Allan (gay): I know some political stuff, I know religious questions, I probably probed them a little bit. So I can come out and be confident in how they'll respond.
>
> Mar (queer): There a lot of strong opinions on the republican side about the queer community and they're not necessarily positive, it causes me to be a bit guarded if I know that someone is extremely republican and I know that I'm super queer, I wonder "What judgments are they making about me? Do they think that my identity is even valid." So communication would be hard for me.
>
> Florence (asexual): So there's a guy who sat next to me, he's a marine, very loud, very opinionated, he did not care about my bubble. I would definitely never tell him because he would never understand. He's very to the point and

when I suggested things to him, he really wouldn't budge very much and I just feel like he'd be one of those people who would say that asexuality doesn't exist, "Why are you saying that? There must be something wrong with you or something."

Several students indicated that they particularly sought out other students whose physical appearance did not match gender norms because they thought that these people would be more accepting of their LGBTQIA identity.

Mar (queer): For me, I end up navigating toward people with non-gender conforming appearances. People who present feminine and have short hair. This person presents masculine but is wearing skinny jeans.

Margaret (bisexual): I mean I think if I saw somebody who looked like they were definitely gay, I would probably rather sit next to them. Maybe I feel like gay people are more accepting of other people regardless, even if they didn't think I was gay.

However, it was not just as simple as finding other LGBTQIA students to sit with because even within the LGBTQIA community, students may not necessarily understand or respect other LGBTQIA identities. Florence, who identifies as asexual, ended up working with Alex, who identifies as transgender, and it became apparent that both of them perceived that the other did not completely understand their experience, even though they both were members of the LGBTQIA community.

Florence (asexual): It took Alex a really long time to come to terms with me being asexual. Because a lot of people don't think it's possible to be that way- they're

like- you're human, you're supposed to want sex- there's something wrong with you if you don't. That's how it is right now.

Alex (trans): Overall I think that the biggest struggle is when someone tries to identify trans, people just visually kind of type you and say whatever comes out first. Florence still calls me "she" from time to time and I'm like "Ugh what is it? What?" And she's like "I don't know, I just say it."

Assigned groups or changing groups during the term led to potential discomfort for most of the LGBTQIA students because of the potential for group members to not be accepting of their identity and the need to re-establish whether or not to come out. However, it seemed to be most uncomfortable for the queer and transgender students who felt as though they must establish their identity since pronouns would likely be used during group interactions. Since both of these students recently transitioned, they were often misidentified as female and had to correct group members for using the wrong pronoun or name. A new group meant having to spend time and energy to come out to the new group and to reestablish comfort in being able to correct other students' misidentification of their gender. In fact, the queer and the trans student both felt very uncomfortable when they came to class late because that meant that they usually had to sit in new groups.

Alex (trans): Sometimes I'm not as comfortable right now with small groups, so I like sticking with the people that I know just because they know how to address me. Not switching groups also kind of saved me the trouble of having to put myself in another situation where I would try to have to correct people or sit there and have people who didn't know me keep misgendering me and then I would be

like “argggg I don’t really know you well enough to bring it up again.” I don't like to have to keep bringing it up. I didn't really like sitting next to people I didn't know because I didn't know how they would kind of take it and even though I have my name tent out, I still get she and her-ed and I’m like “ehhh.” I feel like sometimes in recitation when I switch to another group because I’m always late, I start getting the “shes” and the “hers” and stuff a lot more often and then it kind of makes me question, well what am I doing wrong that I’m not identifying to their standards of a he.

Mar (queer): Because I am working so hard on trying to present myself in a certain way and have people see me as a certain gender, I think that in an active learning classroom, not passing to someone, it makes me feel like crap, which happens a lot. And in an active learning classroom, since you’re communicating with people a lot more than in a traditional setting, not passing to them, and knowing that you don’t pass, I think impacts you more than in a traditional classroom than where if you don't pass to someone you don't really have to recognize it you can ignore it easier because you don’t have to communicate with them again.

In this active learning class, the instructors usually gave students the choice of whom to sit with in groups, although in the beginning of the term, the instructors asked students to sit with a new group in order to try to increase participation among students. In another instance, one instructor offhandedly told students at the beginning of one of the classes that they were going to change groups in the weekly recitation. The instructor ended up deciding not to change groups, however, just the perceived threat that they were

going to change groups was sufficient for Mar, who identifies as queer, to choose not to come to recitation for a few weeks. Further, this student highlighted that the interactions among students in an active learning classroom made it difficult to want to come to an active learning class on days where they did not feel like talking to other people.

> Mar (queer): An active learning classroom is based on communicating with the people around you, so it's really hard when I'm feeling gender dysphoric and I'm not happy and I'm not good and I don't want to be talking to people. It would be helpful to be in a more traditional classroom not having to talk to people and not having to interact with people. I can kind of force myself to go even if I'm feeling not that great but because active learning is based around communicating and talking with others, if I just can't do that that day, then I don't want to go into a setting where I may be forced to do that.

DISCUSSION

Despite the national push to transition STEM classrooms to be more student centered (American Association for the Adcancment of Science, 2011), there is relatively little research on how students perceive active learning environments. However, as we work to create a more diverse and inclusive biology community, it is important to consider who students are, and how their backgrounds and identities influence their experiences within reformed classrooms (Eddy, Brownell, et al., 2015a; Eddy et al., 2014a; K. Tanner & Allen, 2007; K. D. Tanner, 2013a). This study is the first to our knowledge of exploring the experience of LGBTQIA students in active learning undergraduate biology courses. This is an exploratory study that captures the unique and nuanced experiences and opinions of seven students, who identify along the LGBTQIA

spectrum. It is important to acknowledge that the experiences and opinions of these individuals are not intended to be generalizations of that identity (e.g. asexual or gay) or the larger LGBTQIA community. However, from these seven students, common themes from their interviews give insights into how inclusive we are making our biology classrooms and particularly, what we may need to be mindful of when we are converting our classrooms into active learning spaces.

MOVING PAST STIGMAS TOWARDS GREATER UNDERSTANDING AND RESPECT FOR LGBTQIA IDENTITIES

Through these interviews, students expressed that they had concern over coming out to other students and whether it was appropriate to share their LGBTQIA identity. Overall, the student comments reflect an underlying fear of rejection for an identity that they perceive is still stigmatized in the context of a biology classroom.

For instructors to make their classrooms more inclusive and welcoming to this population of students, they can begin by learning about the different identities within the community. Further, instructors may want to improve their own cultural competence regarding LGBTQIA students, which would be the ability of people who identify within a straight or cis-gender culture to understand, communicate, and provide effective services to people who identify within the LGBTQIA culture (K. Tanner & Allen, 2007). Improving instructor cultural competence broadly within active learning biology courses has been highlighted as a critical element of moving toward a more diverse and inclusive scientific community (K. Tanner & Allen, 2007). To help educate both students and instructors, many college and universities provide resources such as LGBTQIA centers and some universities use “Safe Zone” training (Safe Zone Project, n.d.) as a way to

broaden awareness and inclusive practices. There are online resources such as the "Get Educated" section of the online UC Davis LGBTQIA Resource Center: which provides tips, training, and a glossary for those looking to learn more about the LGBTQIA community (University of California, Davis, n.d.). There is a language important for understanding the experiences of LGBTQIA students that may be unfamiliar to some instructors (e.g. "passing", "heteronormative", "gender fluid"), which may be useful for instructors to understand in order to better communicate with these students and more towards inclusive active learning classrooms.

Although the root of a subset of these identities is based on sexual behavior and this may be the reason why students in this study indicated that they felt it was unprofessional to share, the LGBTQIA identity is much broader in scope. Many members of the LGBTQIA communities have moved away from using terms such as "homosexual" or "sexual orientation" because it reduces this identity down to a set of sexual behaviors (Fassinger, 1991; McAllan & Ditllo, n.d.) when in fact the identity extends much further than sexuality alone (e.g. sharing a common ideology, fighting for legal and social acceptance, attending pride events, having a family). In fact, prior studies have demonstrated student discomfort with overtly sexual terms to describe their identity (Lopez & Chism, 1993). Further, LGBTQIA identities encompass gender identity (e.g. transgender) so these components of LGBTQIA identities are not based at all on same-gender sexual attraction. The emphasis on the sexual part of the identity is likely part of the reason why it is perceived by students as too personal to share, so it is important to be mindful of the multiple facets of these identities and the changing landscape of language surrounding this identity.

Instructors can make it explicit that it is acceptable to share this identity in the classroom by collecting information from students at the beginning of the term about their preferred pronoun or name (e.g. having students write this information on index cards) or administering an online survey where students can fill out demographic information, which includes gender and LGBTQIA status. However, instructors should be aware that given some of the negative stigma associated with these identities, students may choose not to disclose. Any of these collection methods should be done voluntarily and students need to have the option of skipping questions and writing in their own responses with their own preferred labels.

One possible way to help LGBTQIA students feel as though they can have that identity and be part of the biology classroom community is to give students examples of LGBTQIA scientists (Gomillion & Giuliano, 2011; LGBT+ Physicists, 2013; National Organization for Gay and Lesbian Scientist and Technical Professionals, n.d.; K. Tanner & Allen, 2007). If an instructor identifies as part of the LGBTQIA community, they may want to consider the positive impacts that their coming out could have on LGBTQIA students in their classes (Mintz & Rothblum, 2013). Prior research has indicated that interpersonal contact with members of the LGBTQIA community can lead to diminished heterosexist attitudes (Herek, 1994; Herek & Glunt, 1993; Liang & Alimo, 2005) and specifically, when instructors come out to their class, student attitudes towards LGBTQIA people generally became more positive (Waldo & Kemp, 1997).

HOW TO MAXIMIZE THE POSITIVES OF ACTIVE LEARNING AND MINIMIZE THE POTENTIAL FOR DISCOMFORT

These students indicated that active learning could lead to them being more comfortable in the class because there are greater opportunities to share their identity and meet others who identify along the LGBTQIA spectrum. However, what became apparent from their responses is that *how* active learning is implemented is important for their overall comfort in the class.

These students indicated that being able to choose where to sit in the classroom and who to work with was very important. In short, they wanted to work with people who would be accepting of their identity. This implies that they likely wanted to avoid people who may make comments that could offend them or others in the community, but further that they wanted the possibility of feeling comfortable enough to come out to their group. Concealing one's identity has been shown to strain social relationships (Ullrich, Lutgendorf, & Stapelton, 2003), so it is likely that these students could have better active learning experiences if they are out to their group. One student, Allan, indicated that he perceived that he engages in higher quality active learning when he is close friends with the people he is working with and that coming out is needed to become close friends. However, whether coming out more broadly has an impact on student learning would need to be further explored with a larger population of LGBTQIA students who have or have not come out to their group.

These findings, while based only on the experiences of seven students, suggest that assigning groups can raise concerns for LGBTQIA students and that allowing students to choose who they want to sit with may alleviate these concerns. The extra cognitive load of needing to establish whether group members might be accepting of one's LGBTQIA identity, debating whether or not to come out, and then going through

the process of coming out means that switching up groups often during the term may lead to significantly more stress on LGBTQIA students that could detract from their learning. While relatively little is known about improving student comfort during groupwork in biology actively learning classrooms, our findings are supported by other studies that have reported that college students who have choice in who they work with report more positive group work experiences than those who do not (Hilton & Phillips, 2010; Mahenthiran & Rouse, 2000). Furthermore, helping students feel more comfortable by allowing them to choose who to work with aligns with a recent study conducted in an active learning biology classrooms that showed that women were more comfortable working in a group with their friends (Eddy, Brownell, et al., 2015a).

If instructors feel strongly about assigning groups for active learning activities, then student perceptions from this study suggest that instructors may want to consider keeping groups consistent for the term. Admittedly, these were only seven students, but six of them indicated that they had higher cognitive load when they were faced with working with a new group of people. Further, based on the experiences of Mar, who described how there were certain days when they emotionally did not want to engage with anyone in part due to their gender dysphoria, instructors might consider giving students the leeway to work individually and not press students to work with a partner.

There is emerging evidence that suggests that whole class discussions in active learning classrooms may be more stressful for students of different identities. For example, in an active learning classroom, women report more anxiety in speaking out in whole class discussions compared in men (Eddy, Brownell, et al., 2015a), Whole class discussions where instructors are calling on specific students may also be more stressful

for transgender students because of the increased risk of public misidentification. However, if the instructor knows that the student is transitioning and can use the preferred gender and name of that student, it can be positive for that student to hear their pronoun or name used in front of everyone. Once the instructors of this class knew that these two students were transitioning, they were able to call the students by their preferred names and use their preferred pronouns. They knew that Alex was transitioning from him writing "he/him/his" on his name tent. They knew that Mar was transitioning from Mar writing an email to one of the teaching assistants and signing it with "Mar, formally Kelcie." While both of these were subtle ways for the students to come out, members of the instructional team picked up on it, changed the pronouns they used for the students, and it made the students feel like their identity was accepted in the classroom.

> Mar (queer): The instructor was really good about using my new name which made me feel really, really good. It made me feel so awesome to be honest because the instructors were actually some of the first people who started calling me that. It was really cool. It made me feel important and accepted in the classroom.

For instructors who are unsure of how to navigate these situations, it is important for them to try not to assume anything of students (e.g. assume that a student is straight or assume that a student is transgender) and to be attentive to subtle cues from students. Most importantly, if instructors can create an environment that is perceived as inclusive, then students will likely be more comfortable sharing this information. In turn,

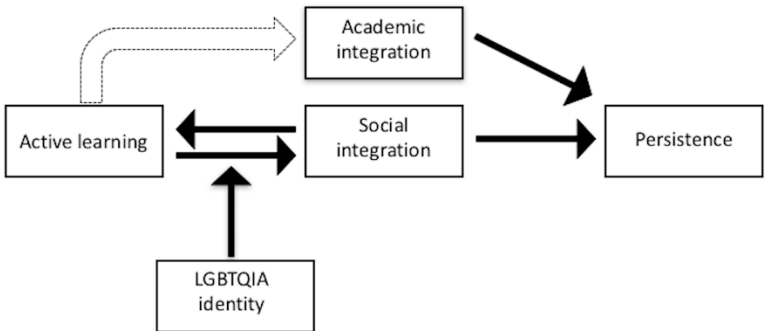
instructors may need to be flexible in their instructional practices (e.g. changing the name in the gradebook) to help students feel comfortable in their active learning classrooms.

MODIFYING TINTO'S THEORY OF COLLEGE STUDENT DEPARTURE: FROM A LINEAR RELATIONSHIP BETWEEN ACTIVE LEARNING AND SOCIAL INTEGRATION TO A RECIPROCAL RELATIONSHIP BETWEEN ACTIVE LEARNING AND SOCIAL INTEGRATION

Tinto's theory posited that collaborative learning activities in the classroom (e.g. active learning) leads to social integration, which can be linked to positive impacts on student retention (Braxton et al., 2000; Severiens & Schmidt, 2009; Tinto, 1997a). We used this theory to explore the impact of social identities, specifically LGBTQIA identities, on student social integration in the context of active learning. In this study, we find that these students perceive their LGBTQIA identity to affect their social integration, unfortunately often in negative ways. If extrapolated, this could mean that the lower social integration could lead to decreased LGBTQIA student persistence in college.

However, we propose a modification to this linear relationship between active learning and social integration. Our findings suggest that the relationship between active learning and social integration is actually reciprocal: active learning can lead to more social integration, but higher levels of social integration could also lead to higher engagement in and potential benefit from active learning (Figure 2.2).

Figure 2.2. A Modified Model of Tinto's Theory of College Student Departure That Includes a Reciprocal Relationship Between Active Learning and Social Integration



For students who develop higher social integration in the classroom, the higher social integration likely extends to other college settings (e.g. clubs or future classes), which can influence student retention (Tinto, 1975, 1997a). However, that higher social integration in the class can also lead to greater engagement in the active learning itself. This may allow students to move away from superficial discussions of the course material to more sophisticated discussions, including more interactive peer discussions with greater explanations for their reasoning, which is speculated to lead to more learning (Knight, Wise, & Southard, 2013). This greater academic benefit could be conceptualized as academic integration, which was originally part of Tinto's theory and encapsulates earning good grades and high levels of intellectual development (Tinto, 1975).

Thus, this modified theory suggests that social integration can directly lead to student persistence in college. In addition, social integration can indirectly lead to student persistence through better engagement in active learning, which leads to academic integration. In contrast, students who may not establish social integration for any number of reasons would not gain the direct or indirect benefits for retention. We

predict that social identities, particularly identities that are in minority status, influence social integration and that a lack of social integration in active learning classrooms could be a reason why particular social identities are at risk for attrition.

This study on the experiences of LGBTQIA students supports components of that assertion. These students generally feel that their LGBTQIA identity is socially unacknowledged or unaccepted in the biology classroom and this can affect how comfortable they feel doing groupwork in active learning classes. Feeling uncomfortable in groups could lead to less social integration in their group, which could cause them to withdraw from the active learning exercises, especially activities that were predicated on groupwork. In contrast, feeling comfortable with their group members, and for some this meant coming out to group members, led to more engagement in active learning. We hypothesize that student comfort in groupwork is essential for this social integration and is a factor that instructors and education researchers should examine further in the context of active learning. We also recommend that future research be done to explore how social integration can affect retention for this population of students.

Finally, the cognitive load that some students experience when considering their LGBTQA identity in an active learning classroom may detract from their learning. While this may not impact social integration itself, it can influence the quality of the active learning. Active learning can provide students with more opportunities to interact with other students and instructors and such opportunities may be more likely to lead to isolation than integration if a student does not feel comfortable in the classroom considering their identity. Enhancing student active learning experiences by maximizing

all students' opportunities to feel socially accepted in the active learning classroom is an important step in creating a more diverse and inclusive biology community.

LIMITATIONS

As with any interview study, there could be a volunteer bias associated with these particular people who volunteered to participate in the study that could skew the data. However, given the national data that estimates around 3.6% of the population identifies as LGBTQIA (Inc, n.d.), we ended up interviewing 3.9% of the class, which is likely close to the total percentage of LGBTQIA students in the class.

During these interviews, many of the students indicated that they had never been asked to talk about their LGBTQIA identities in relation to the biology community, or their biology courses, so it is possible that if students were given more time to think about these issues, their responses may have been different. This calls for a need to do longitudinal studies of this population of students, some of which are ongoing (e.g. (National Study of LGBTQ Student Success, n.d.)National Study of LGBTQ Student Success, 2013).

DIRECTIONS FOR FURTHER RESEARCH

We felt as though the best way to begin exploring LGBTQIA student experiences in active learning was to embed the study in the context of a single active learning classroom in order to identify how, if at all, specific elements of an active learning classroom were influenced by students LGBTQIA identities. Further research should explore whether these student experiences are shared by other members of the LGBTQIA community in different active learning classrooms and in other geographic locations. This study was conducted in a politically conservative state that has historically been

anti-LGBTQIA. Thus, the experience of LGBTQIA students in a more liberal state could be considerably different. While this study was conducted in a state that has not necessarily been friendly to LGBTQIA individuals, it was conducted at a public institution that has SafeZone training. It would also be interesting to explore the experiences of LGBTQIA students at private institutions, particularly some religious institutions that have been vocally anti-LGBTQIA. We invite instructors from other institutions in different parts of the country to explore whether students at their universities share similar experiences. This exploratory work could set the stage for more large-scale, national studies. In addition, we need to explore the experiences of multiple students who hold the same identity (e.g. asexual) to see the extent to which these student experiences are generalizable.

Furthermore, we suspect that student experiences in active learning classrooms may ultimately impact retention in college which is consistent with Tinto's theory of college student departure. In this study we only interviewed students who identified as life sciences majors and were currently pursuing undergraduate degrees. Additional studies could focus on LGBTQIA students who have left STEM majors or college to identify whether experiences in active learning classrooms and a lack of social integration contributed to their departure from the major or from college.

DISCLAIMER ABOUT TOLERANCE AND ACCEPTANCE

Several students indicated in their quotes that they actively avoided members of fraternities/sororities, religious organizations, and politically conservative groups. We include these statements because they are the students' opinions and experiences and these examples illustrate the complexity of how these students feel they need to navigate

the active learning classroom. These examples are similar to the opinions expressed by LGBTQIA individuals in other studies (Patridge et al., 2014) and reflect established historic and current discrimination correlated with membership in these groups (Goodstein, 2015; Holland et al., 2013; Hooghe et al., 2010). Our students were clear that they knew that not every member of a group holds the same attitudes towards LGBTQIA individuals, but that they needed to maximize the probability that their group members would be accepting of their identity. We encourage members of fraternities/sororities, religious organizations, and politically conservative groups to challenge these LGBTQIA students assumptions about their intolerance and build bridges between these different communities.

CONCLUSION

Through an exploratory interview study of seven students holding unique identities along the LGBTQIA spectrum, we examined the experiences and perceptions of LGBTQIA students in an active learning biology class. We hope that this research will draw awareness to the diversity of student experiences in active learning classrooms and help our classrooms become more inclusive for this population of students.

ACKNOWLEDGEMENTS

We thank the students for coming out to the interviewer and sharing their unique experiences and thoughts. We thank Sarah Eddy, Cara Gormally, and Christian Wright their thoughtful feedback on the manuscript.

REFERENCES

American Association for the Adcancment of Science. (2011). Vision and Change in Undergraduate Biology Education: A Call to Action. Washington, DC: CBE-LIfe Science Education. Retrieved from http://visionandchange.org/files/2013/11/aaas-VISchange-web1113.pdf

American Physical Society. (2016). LGBT Climate in Physics: Building and Inclusive Community. College Park, MD. Retrieved from https://www.aps.org/programs/lgbt/upload/LGBTClimateinPhysicsReport.pdf

Bilimoria, D., & Stewart, A. J. (2009). "Don't Ask, Don't Tell": The Academic Climate for Lesbian, Gay, Bisexual, and Transgender Faculty in Science and Engineering. *NWSA Journal*, *21*(2), 85–103.

Braun, V., & Clarke, V. (2009). Coming out and negotiating heteronormativity in higher education. *Lesbian & Gay Psychology Review*, *10*(1), 3–7.

Braxton, J. M., Milem, J. F., & Sullivan, A. S. (2000). The influence of active learning on the college student departure process: Toward a revision of Tinto's theory. *The Journal of Higher Education*, *71*(5), 569–590.

Caballero, N. (2013, July 12). *Attitudes and beliefs towards LGBTQ community in a college campus* (Thesis). Retrieved from http://scholarworks.calstate.edu/handle/10211.9/2217

Calzo, J. P., Antonucci, T. C., Mays, V. M., & Cochran, S. D. (2011). Retrospective Recall of Sexual Orientation Identity Development Among Gay, Lesbian, and Bisexual Adults. *Developmental Psychology*, *47*(6), 1658–1673. https://doi.org/10.1037/a0025508

Cech, E. A. (2015). LGBT Professionals' Workplace Experiences in STEM-Related Federal Agencies (p. 26.1094.1-26.1094.10). Presented at the 2015 ASEE Annual Conference & Exposition. Retrieved from https://peer.asee.org/lgbt-professionals-workplace-experiences-in-stem-related-federal-agencies

Cech, E. A., & Waidzunas, T. J. (2011). Navigating the heteronormativity of engineering: the experiences of lesbian, gay, and bisexual students. *Engineering Studies*, *3*(1), 1–24. https://doi.org/10.1080/19378629.2010.545065

Chrobot-Mason, D., Button, S. B., & DiClementi, J. D. (2001). Sexual Identity Management Strategies: An Exploration of Antecedents and Consequences. *Sex Roles*, *45*(5–6), 321–336. https://doi.org/10.1023/A:1014357514405

D'Augelli, A. R., Hershberger, S. L., & Pilkington, N. W. (1998). Lesbian, gay, and bisexual youth and their families: disclosure of sexual orientation and its consequences. *The American Journal of Orthopsychiatry*, *68*(3), 361-371; discussion 372-375.

de Monteflores, C., & Schultz, S. J. (1978). Coming Out: Similarities and Differences for Lesbians and Gay Men. *Journal of Social Issues*, *34*(3), 59–72. https://doi.org/10.1111/j.1540-4560.1978.tb02614.x

Dugan, J. P., & Yurman, L. (2011). Commonalities and Differences Among Lesbian, Gay, and Bisexual College Students: Considerations for Research and Practice. *Journal of College Student Development*, *52*(2), 201–216. https://doi.org/10.1353/csd.2011.0027

Eddy, S. L., Brownell, S. E., Thummaphan, P., Lan, M.-C., & Wenderoth, M. P. (2015). Caution, Student Experience May Vary: Social Identities Impact a Student's Experience in Peer Discussions. *CBE-Life Sciences Education*, *14*(4), ar45. https://doi.org/10.1187/cbe.15-05-0108

Eddy, S. L., Brownell, S. E., & Wenderoth, M. P. (2014). Gender gaps in achievement and participation in multiple introductory biology classrooms. *CBE Life Sciences Education*, *13*(3), 478–492. https://doi.org/10.1187/cbe.13-10-0204

Eddy, S. L., Converse, M., & Wenderoth, M. P. (2015). PORTAAL: A Classroom Observation Tool Assessing Evidence-Based Teaching Practices for Active Learning in Large Science, Technology, Engineering, and Mathematics Classes. *CBE-Life Sciences Education*, *14*(2), ar23. https://doi.org/10.1187/cbe.14-06-0095

Eddy, S. L., & Hogan, K. A. (2014). Getting Under the Hood: How and for Whom Does Increasing Course Structure Work? *CBE-Life Sciences Education*, *13*(3), 453–468. https://doi.org/10.1187/cbe.14-03-0050

Etengoff, C., & Daiute, C. (2014). Family members' uses of religion in post–coming-out conflicts with their gay relative. *Psychology of Religion and Spirituality*, *6*, 33–43.

Fassinger, R. E. (1991). The Hidden Minority: Issues and Challenges in Working with Lesbian Women and Gay Men. *The Counseling Psychologist*, *19*(2), 157–176. https://doi.org/10.1177/0011000091192003

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Freeman, S., Theobald, R., Crowe, A. J., & Wenderoth, M. P. (2017). Likes attract: Students self-sort in a classroom by gender, demography, and academic characteristics. *Active Learning in Higher Education*, *18*(2), 115–126. https://doi.org/10.1177/1469787417707614

Goffman, E. (1986). *Stigma: Notes on the Management of Spoiled Identity*. Touchstone. Retrieved from http://www.simonandschuster.com/books/Stigma/Erving-Goffman/9780671622442

Gomillion, S. C., & Giuliano, T. A. (2011). The Influence of Media Role Models on Gay, Lesbian, and Bisexual Identity. *Journal of Homosexuality*, *58*(3), 330–354. https://doi.org/10.1080/00918369.2011.546729

Goodstein, L. (2015, November 6). Mormons Sharpen Stand Against Same-Sex Marriage. *The New York Times*. Retrieved from https://www.nytimes.com/2015/11/07/us/mormons-gay-marriage.html

Griffith, K. H., & Hebl, M. R. (2002). The disclosure dilemma for gay men and lesbians: "coming out" at work. *The Journal of Applied Psychology*, *87*(6), 1191–1199.

Herek, G. M. (1988). Heterosexuals' attitudes toward lesbians and gay men: Correlates and gender differences. *The Journal of Sex Research*, *25*(4), 451–477. https://doi.org/10.1080/00224498809551476

Herek, G. M. (1994). Assessing Heterosexuals' Attitudes toward Lesbians and Gay Men: A Review of Empirical Research with the ATLG Scale. In *Lesbian and Gay Psychology: Theory, Research, and Clinical Applications* (pp. 206–228). Thousand Oaks: SAGE Publications, Inc. https://doi.org/10.4135/9781483326757

Herek, G. M., & Glunt, E. K. (1993). Interpersonal contact and heterosexuals' attitudes toward gay men: Results from a national survey. *The Journal of Sex Research*, *30*(3), 239–244. https://doi.org/10.1080/00224499309551707

Hilton, S., & Phillips, F. (2010). Instructor-Assigned and Student-Selected Groups: A View from Inside. *Issues in Accounting Education*, *25*(1), 15–33. https://doi.org/10.2308/iace.2010.25.1.15

Holland, L., Matthews, T. L., & Schott, M. R. (2013). "That's so gay!" Exploring college students' attitudes toward the LGBT population. *Journal of Homosexuality*, *60*(4), 575–595. https://doi.org/10.1080/00918369.2013.760321

Hooghe, M., Claes, E., Harell, A., Quintelier, E., & Dejaeghere, Y. (2010). Anti-gay sentiment among adolescents in Belgium and Canada: a comparative investigation into the role of gender and religion. *Journal of Homosexuality*, *57*(3), 384–400. https://doi.org/10.1080/00918360903543071

Human Rights Campaign. (n.d.). The Cost of the Closet and the Rewards of Inclusion. Retrieved February 11, 2018, from https://www.hrc.org/resources/the-cost-of-the-closet-and-the-rewards-of-inclusion/

Inc, G. (n.d.). San Francisco Metro Area Ranks Highest in LGBT Percentage. Retrieved February 11, 2018, from http://news.gallup.com/poll/182051/san-francisco-metro-area-ranks-highest-lgbt-percentage.aspx

Kerr, D. L., Santurri, L., & Peters, P. (2013). A comparison of lesbian, bisexual, and heterosexual college undergraduate women on selected mental health issues. *Journal of American College Health: J of ACH*, *61*(4), 185–194. https://doi.org/10.1080/07448481.2013.787619

Kinnish, K. K., Strassberg, D. S., & Turner, C. W. (2005). Sex differences in the flexibility of sexual orientation: a multidimensional retrospective assessment. *Archives of Sexual Behavior*, *34*(2), 173–183. https://doi.org/10.1007/s10508-005-1795-9

Kitzinger, C. (n.d.). Heteronormativity in Action: Reproducing the Heterosexual Nuclear Family in After-hours Medical Calls, *52*(4), 477–498. https://doi.org/10.1525/sp.2005.52.4.477

Knight, J. K., Wise, S. B., & Southard, K. M. (2013). Understanding Clicker Discussions: Student Reasoning and the Impact of Instructional Cues. *CBE-Life Sciences Education*, *12*(4), 645–654. https://doi.org/10.1187/cbe.13-05-0090

LGBT+ Physicists. (2013). Supporting LGBT+ Physicists: A Best Practices Guide for Departments. Presented at the AAS Working Group on LGBTIQ Equality., Washington, DC. Retrieved from http://lgbtphysicists.org/files/BestPracticesGuide.pdf

Liang, C. T. H., & Alimo, C. (2005). The Impact of White Heterosexual Students' Interactions on Attitudes Toward Lesbian, Gay and Bisexual People: A Longitudinal Study. *Journal of College Student Development*, *46*(3), 237–250. https://doi.org/10.1353/csd.2005.0028

Lombardi, E. (2009). Varieties of transgender/transsexual lives and their relationship with transphobia. *Journal of Homosexuality*, *56*(8), 977–992. https://doi.org/10.1080/00918360903275393

Lombardi, E. L., Wilchins, R. A., Priesing, D., & Malouf, D. (2001). Gender violence: transgender experiences with violence and discrimination. *Journal of Homosexuality*, *42*(1), 89–101.

Lopez, G., & Chism, N. (1993). Classroom Concerns of Gay and Lesbian Students: The Invisible Minority. *College Teaching*, *41*(3), 97–103.

Love, P. (1997). Contradiction and Paradox: Attempting to Change the Culture of Sexual Orientation at a Small Catholic College. *The Review of Higher Education*, *20*(4), 381–398. https://doi.org/10.1353/rhe.1997.0009

Love, P. G. (1998). Cultural Barriers Facing Lesbian, Gay, and Bisexual Students at a Catholic College. *The Journal of Higher Education*, *69*(3), 298–323. https://doi.org/10.2307/2649190

Mahenthiran, S., & Rouse, P. J. (2000). The impact of group selection on student performance and satisfaction. *International Journal of Educational Management*, *14*(6), 255–265. https://doi.org/10.1108/09513540010348043

McAllan, L. C., & Ditllo, D. (n.d.). Addressing the needs of lesbian and gay clients with disabilities. *Journal of Applied Rehabilitation Counseling*, *25*, 26–35.

McCarn, S. R., & Fassinger, R. E. (1996). Revisioning Sexual Minority Identity Formation: A New Model of Lesbian Identity and its Implications for Counseling and Research. *The Counseling Psychologist*, *24*(3), 508–534. https://doi.org/10.1177/0011000096243011

McKinney, J. S. (2005). On the Margins: A Study of the Experiences of Transgender College Students. *Journal of Gay & Lesbian Issues in Education*, *3*(1), 63–76.

Mintz, B., & Rothblum, E. D. (2013). *Lesbians in Academia: Degrees of Freedom*. Routledge.

Mishel, E. (2016). Discrimination against Queer Women in the U.S. Workforce: A Résumé Audit Study. *Socius*, *2*, 2378023115621316. https://doi.org/10.1177/2378023115621316

Mizzi, R. C. (2013). "There aren't any gays here": encountering heteroprofessionalism in an international development workplace. *Journal of Homosexuality*, *60*(11), 1602–1624. https://doi.org/10.1080/00918369.2013.824341

Morgan, E. M. (2013). Contemporary Issues in Sexual Orientation and Identity Development in Emerging Adulthood. *Emerging Adulthood*, *1*(1), 52–66. https://doi.org/10.1177/2167696812469187

Morse, J. M., Barrett, M., Mayan, M., Olson, K., & Spiers, J. (2002). Verification Strategies for Establishing Reliability and Validity in Qualitative Research. *International Journal of Qualitative Methods*, *1*(2), 13–22. https://doi.org/10.1177/160940690200100202

Nagoshi, J. L., Adams, K. A., Terrell, H. K., Hill, E. D., Brzuzy, S., & Nagoshi, C. T. (2008). Gender Differences in Correlates of Homophobia and Transphobia. *Sex Roles*, *59*(7–8), 521. https://doi.org/10.1007/s11199-008-9458-7

National Organization for Gay and Lesbian Scientist and Technical Professionals. (n.d.). Queer Scientists of Historical Note – NOGLSTP. Retrieved February 11, 2018, from https://www.noglstp.org/publications-documents/queer-scientists-of-historical-note/

National Science Foundation/National Center for Science and Engineering. (n.d.). Women, Minorities, and Persons with Disabilities in Science and Engineering - NCSES - US National Science Foundation (NSF). Retrieved February 11, 2018, from https://www.nsf.gov/statistics/2017/nsf17310/

National Study of LGBTQ Student Success. (n.d.). National Study of LGBTQ Student Success. Retrieved February 14, 2018, from http://www.lgbtqsuccess.net/About.html

Newman, B. S., & Muzzonigro, P. G. (1993). The effects of traditional family values on the coming out process of gay male adolescents. *Adolescence*, *28*(109), 213–226.

Obergefell V Hodges (Supreme Court of the United States June 26, 2015). Retrieved from https://www.supremecourt.gov/opinions/14pdf/14-556_3204.pdf

Orlov, J. M., & Allen, K. R. (2014). Being who I am: effective teaching, learning, student support, and societal change through LGBQ faculty freedom. *Journal of Homosexuality*, *61*(7), 1025–1052. https://doi.org/10.1080/00918369.2014.870850

Patridge, E. V., Barthelemy, R. S., & Rankin, S. R. (2014). FACTORS IMPACTING THE ACADEMIC CLIMATE FOR LGBQ STEM FACULTY. *Journal of Women and Minorities in Science and Engineering*, *20*(1). https://doi.org/10.1615/JWomenMinorScienEng.2014007429

Perez, R., DeBord, K., & Bieschke, K. (2000). Coming out: lesbian, gay, and bisexual identity development. In *Handbook of Counseling and Psychotherapy with Lesbian, Gay, and Bisexual Clients, ed*. Washington, DC: American Psychological Association.

Quinn, D. M. (2006). Concealable versus conspicuous stigmatized identities. In *Stigma and Group Inequality: Social Psychological Perspectives* (pp. 83–103). Mahwah, NJ: Psychology Press.

Rankin, S. (2003). Campus Climate for LGBT People: A National Perspective. Presented at the National Gay and Lesbian Task Force Policy Institute, New York.

Rhoads, R. A. (1994). *Coming Out in College: The Struggle for a Queer Identity*. Greenwood Publishing Group.

Russ, T., Simonds, C., & Hunt, S. (2002). Coming Out in the Classroom... An Occupational Hazard?: The Influence of Sexual Orientation on Teacher Credibility and Perceived Student Learning. *Communication Education*, *51*(3), 311–324. https://doi.org/10.1080/03634520216516

Rust, P. C. (1993). "COMING OUT" IN THE AGE OF SOCIAL CONSTRUCTIONISM:: Sexual Identity Formation among Lesbian and Bisexual Women. *Gender & Society*, *7*(1), 50–77. https://doi.org/10.1177/089124393007001004

Safe Zone Project. (n.d.). Home page. Retrieved February 14, 2018, from http://thesafezoneproject.com/

Severiens, S. E., & Schmidt, H. G. (2009). Academic and social integration and study progress in problem based learning. *Higher Education*, *58*(1), 59. https://doi.org/10.1007/s10734-008-9181-x

Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. *Cognitive Science*. Retrieved from http://onlinelibrary.wiley.com.ezproxy1.lib.asu.edu/doi/10.1207/s15516709cog1202_4/abstract?utm_source=Brilliant%3A+The+New+Science+of+Smart+Newsletter&utm_campaign=a3cc927251-Brilliant_Report_16_1_2012&utm_medium=email&utm_term=0_9c734401c1-a3cc927251-311323697

Tanner, K., & Allen, D. (2007). Cultural Competence in the College Biology Classroom. *CBE-Life Sciences Education*, *6*(4), 251–258. https://doi.org/10.1187/cbe.07-09-0086

Tanner, K. D. (2013). Structure Matters: Twenty-One Teaching Strategies to Promote Student Engagement and Cultivate Classroom Equity. *CBE-Life Sciences Education*, *12*(3), 322–331. https://doi.org/10.1187/cbe.13-06-0115

Taylor, S. J., Bogdan, R., & DeVault, M. (2015). *Introduction to Qualitative Research Methods: A Guidebook and Resource*. John Wiley & Sons.

Tinto, V. (1975). Dropout from Higher Education: A Theoretical Synthesis of Recent Research. *Review of Educational Research*, *45*(1), 89–125. https://doi.org/10.3102/00346543045001089

Tinto, V. (1997). Classrooms as Communities. *The Journal of Higher Education*, *68*(6), 599–623. https://doi.org/10.1080/00221546.1997.11779003

Ullrich, P. M., Lutgendorf, S. K., & Stapelton, J. T. (2003). Concealment of homosexual identity, social support and CD4 cell count among HIV-seropositive gay men. *Journal of Psychosomatic Research*. https://doi.org/10.1016/S0022-3999(02)00481-6

University of California, Davis. (n.d.). Get Educated. Retrieved February 14, 2018, from http://lgbtqia.ucdavis.edu/educated/index.html

Vaccaro, A. (2006). Gay, lesbian, bisexual, and transgender students. In: Understanding College Student Subpopulations: A Guide for Student Affairs Professionals, ed. (pp. 349–386). Presented at the National Association of Student Personnel Administrators, Washington, DC.

Waldo, C. R., & Kemp, J. L. (1997). Should I come out to my students? An empirical investigation. *Journal of Homosexuality*, *34*(2), 79–94.

Worthen, M. G. F. (2014). Blaming the Jocks and the Greeks?: Exploring Collegiate Athletes' and Fraternity/Sorority Members' Attitudes Toward LGBT Individuals. *Journal of College Student Development*, *55*(2), 168–195.

CHAPTER 3

WHO PERCEIVES THEY'RE SMARTER? EXPLORING THE INFLUENCE OF STUDENT CHARACTERISTICS ON STUDENT ACADEMIC SELF-CONCEPT IN PHYSIOLOGY

ABSTRACT

Academic self-concept is one's perception of his or her ability in an academic domain and is formed by comparing oneself to other students. As college biology classrooms transition from lecturing to active learning, students interact more with each other and are likely comparing themselves more to other students in the class. Student characteristics can impact students' academic self-concept, however this has been unexplored in the context of undergraduate biology. In this study, we explored whether student characteristics can affect academic self-concept in the context of an active-learning college physiology course. Using a survey, students self-reported how smart they perceived themselves in the context of physiology relative to the whole class and relative to their groupmate- the student they worked most closely with in class. Using linear regression, we found that males and native English speakers had significantly higher academic self-concept relative to the whole class compared with females and non-native English speakers. Using logistic regression, we found that males had significantly higher academic self-concept relative to their groupmate compared with females. Using constant comparison methods, we identified nine factors that students reported influenced how they determined whether they are more or less smart than their groupmate. Finally, we found that students were more likely to report participating more than their groupmate if they had a higher academic self-concept. These findings suggest that student

characteristics can influence students' academic self-concept, which in turn may influence their participation in small group discussion and their academic achievement in active learning classes.

While numerous factors have been shown to influence student learning and retention in undergraduate biology, an understudied area is the importance of affective components of learning ("Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering," 2012; Trujillo & Tanner, 2014; Vermunt, 1996; "Vision and Change in Undergraduate Biology Education: Chronicling Change, Inspiring the Future," 2015)("Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering," 2012; "Vision and Change in Undergraduate Biology Education: Chronicling Change, Inspiring the Future," 2015; Trujillo & Tanner, 2014; Vermunt, 1996). Recently, biology education researchers have increasingly turned their attention to exploring student affective constructs including sense of belonging (Corwin, Graham, & Dolan, 2015; A. C. Johnson, 2007; Ong, Wright, Espinosa, & Orfield, 2011; J. L. Smith, Lewis, Hawthorne, & Hodges, 2013; Trujillo & Tanner, 2014), self-efficacy (Adedokun, Bessenbacher, Parker, Kirkham, & Burgess, 2013; Trujillo & Tanner, 2014; Uitto, 2014), comfort (Eddy, Brownell, Thummaphan, Lan, & Wenderoth, 2015b), and science identity (Carlone & Johnson, 2007; Corwin et al., 2015; Trujillo & Tanner, 2014). One affective construct that has not been explored in the context of college biology classrooms is student academic self-concept.

Academic self-concept is one's perception of his or her own ability in a specific academic domain (e.g. statistics, ecology, physiology) and is developed by one's experiences within a learning environment including academic interactions with peers and instructors (Brunner, Keller, Hornung, Reichert, & Martin, 2009a; H.W. Marsh & Craven, 1997; Shavelson, Hubner, & Stanton, 1976a). Academic self-concept is strongly

influenced by one's perceptions of the academic abilities of other students and can be measured by assessing a student's perception of his or her academic ability in a domain compared with a group of peers in that domain (H.W. Marsh & Craven, 1997).

Prior research on academic self-concept has shown that it can influence other affective constructs such as self-efficacy and student motivation, as well as student in-class participation. Self-efficacy is defined as students' confidence in their ability to perform a task (Bong & Skaalvik, 2003) and is distinct from academic self-concept. Students develop self-efficacy by considering their abilities compared to the goal they are trying to achieve (Bong & Skaalvik, 2003), while students develop academic self-concept by comparing their academic abilities in a domain with the academic abilities of other students (Bong & Skaalvik, 2003). Ferla and colleagues found that high school students' academic self-concept in math strongly influenced their math self-efficacy or their belief that they would do well in the math course. However, there was not a reciprocal relationship between these two constructs; student self-efficacy did not influence student academic self-concept (Ferla, Valcke, & Cai, 2009). Academic self-concept has also been shown to increase student motivation. In a study conducted with undergraduate students studying education, academic self-concept in education was found to be the strongest predictor of student motivation to study material for the course (Ommundsen, Haugen, & Lund, 2005). Similarly, students' academic self-concept in the context of a high school math course directly influenced their motivation to complete their math homework (Guay, Ratelle, Roy, & Litalien, 2010). Lastly, there is some evidence to suggest that a students' academic self-concept may influence their participation in class. In an interview study exploring undergraduate resistance to active learning, some biology

students expressed they were reluctant to participate in small group discussion because they were afraid that other students might perceive them as less intelligent (K.M. Cooper, Soneral, & Brownell, n.d.). Further, in a case study of graduate students, non-native English speakers expressed that one reason they are quiet during class is because they feel that their language abilities and content knowledge are insufficient to express themselves clearly (Tatar, 2005).

Student characteristics, such as gender, race/ethnicity, and anxiety level, have been shown to influence student academic self-concept. For example, female high school students studying physics and chemistry were found to have a lower academic self-concept in each of these domains compared with males, even after controlling for a measure of academic ability (Jansen, Schroeders, & Lüdtke, 2014). Similarly, high school females have been shown to have lower academic self-concept in math compared with their male peers (Nagy, Trautwein, Baumert, Köller, & Garrett, 2006). Student race/ethnicity has also been shown to influence academic self-concept. In a study exploring first-generation college students' math academic self-concept, Asian and Latino/a students had significantly higher math academic self-concept compared to African American students; white students' math academic self-concept did not differ significantly from any other racial or ethnic group (DeFreitas, 2013). Student anxiety level in the classroom may also be related to student academic self-concept. Students with low academic self-concept in nursing have been shown to be more likely to have high anxiety in academic settings (Khalaila, 2015). Thus, a student's characteristics may influence the development of their academic self-concept in a specific domain.

One framework describing the development of student academic self-concept is the Internal/External Frame-of-Reference model, which suggests that academic self-concept is formed by both (1) internal comparisons or a student's comparison of his or her abilities in different domains (e.g. a student's ability in math compared to his ability in English) and (3) external comparisons when a student compares his or her ability in a domain to the abilities of other students (H.W. Marsh & Craven, 1997). Historically, studies have explored external comparisons by measuring students' conceptions of their abilities as they compare with the abilities of a large group of peers in a domain (e.g. an entire class). However, we propose that a student's external frame-of-reference can also be formed by the student's perception of his or her academic ability compared to another student whom he or she works closely with in class. In a class where a student's frame of reference is largely based on who he or she works with during class, then groupmates would likely influence the development of that student's academic self-concept. Thus, a student in physiology has an academic self-concept in physiology relative to the collective ability of the class as a whole, but he or she also has an academic self-concept relative to the ability of a single student in class with whom he or she works with closely; these two academic self-concepts may be different depending on how similar the person they work most closely with is to the rest of the class. For example, a student may perceive that she is smarter than most of the students in her physiology class and thus have a high academic self-concept relative to the class as a whole, but she may perceive that the groupmate she works with on problems in class is much better at physiology then she is and thus, she would have a low academic self-concept relative to that particular

groupmate. Both perceptions may influence a student's overall academic self-concept in physiology.

As we transition college sciences courses from traditional lecture to student-centered active learning, there are more opportunities for students to compare themselves to other students in the class. In active learning classes, students regularly have opportunities to compare themselves to the whole class. For example, instructors in active learning often use clicker questions to poll the class about a concept and then instructors often reveal what the class as a whole answered and sometimes what percentage of the class answered it correctly. Thus, students can compare their own answer to the answers of the class and get a sense for how many other students had the correct answer. Students also have opportunities to compare themselves to individual students in the class. Sometimes instructors pair clicker questions with whole class discussions where instructors ask individual students to share their ideas in front of the class, so everyone in the class can compare their own thinking to that student's thinking. Commonly, instructors have students work in partners or small groups in active learning where students frequently share their ideas and hear the ideas of a small number (~1-3) of other students. Because of these repeated interactions, we propose that students likely develop an academic self-concept in biology relative to individuals whom they work with frequently in addition to an academic self-concept relative to the whole class. We predict that students' characteristics may have an even greater influence on their academic self-concept relative to a student in their group because previous studies have shown that students' characteristics can influence their experiences in active learning classrooms where students are working in groups (Cooper & Brownell, 2016a; Eddy, Brownell, et

al., 2015b). For example, Eddy, Brownell, and colleagues showed that males are more likely than females to prefer a leader/explainer role in a small group and females are more comfortable in small groups when they work with a friend (Eddy, Brownell, et al., 2015b). Further, LGBTQIA students report being concerned that students with whom they work during class will perceive them as less competent if their LGBTQIA identity is revealed (Cooper & Brownell, 2016a). These studies highlight that student characteristics can influence student experiences in active-learning classrooms, but it is unclear whether these characteristics could also affect student academic self-concept in biology, and particularly their academic self-concept relative to other students they work with in active-learning classes. Further, it is unknown whether a student's academic self-concept in biology has an impact on student experience in the classroom, particularly whether academic self-concept influences how students interact during active learning.

In this study, we explored student academic self-concept in an upper-level physiology course taught in an active learning way. We set out to answer the following research questions:

1. To what extent do student characteristics predict student academic self-concept in biology, specifically physiology, relative to the whole class?
2. To what extent do student characteristics predict student academic self-concept in physiology relative to the student they worked most closely with in class (hereafter referred to as "groupmate")?
3. How do students determine their academic self-concept relative to their groupmate?

4. To what extent does student academic self-concept in physiology predict self-reported student participation in peer discussion?

METHODS

COURSE DESCRIPTION

All data were collected from a large-enrollment, upper level physiology course comprised of 244 students. The class was taught in an active-learning way; every class session included student-centered instruction, typically using a combination of groupwork using worksheets and clicker questions. During clicker questions, students typically first answered a question individually and then discussed with their neighbor before answering the question again. During the debrief of the clicker question, the instructor would typically repeat out student ideas that she heard while walking around during the peer discussion, but there was no whole class discussion where single students spoke out in-front of the whole class. The instructor would also show students a histogram of their responses to the question. Thus, a student could compare how he or she answered the question to how the other students in the class answered in aggregate. Students had the opportunity to choose where they sat every class period and were not assigned to groups. However, most students chose to sit in the same general area during every class period and worked with the same student(s) during class; only 9% of students reported that they did not sit in the same section during most class periods. The class met three times a week for 50 minutes each.

DATA COLLECTION

During the first week of class, all students were asked to complete a demographic survey. Students were asked to report out their demographic information including

gender, race/ethnicity, whether the student was a native English speaker, and whether the student transferred to the institution from a 2-year institution. Students were also asked a yes/no question about whether they had ever struggled with an anxiety disorder. Of the 244 students enrolled in the class, 230 students (94%) completed this survey. To assess students' academic self-concept, students were surveyed again at the end of the seventh week of class, after relationships with other students had been established, but before the first exam in this course. We chose to survey students before the first exam so that students' grades on the first exam did not influence their academic self-concept. Although students would have had opportunities to estimate their standing in the course through other assignments, including pre-class reading quizzes, in-class clicker questions, and practice exam questions, they did not yet have their score on a high stakes summative assessment to compare to other students. Of the 244 students in the class, 218 students (89%) completed the second survey. Two-hundred and two students (83% of students enrolled in the class) completed both surveys and are included in the dataset. To determine students' academic self-concept in physiology relative to the whole class, all students reported the percentage of the whole class that they perceived they are smarter than in the context of physiology. Students also indicated whether they regularly worked with other students in the physiology course. Student academic self-concept relative to the person they worked most closely with in class was only analyzed for students who indicated that they worked regularly with other students in physiology lecture (190 students, 94% of students with a complete dataset). The person that they worked most closely with in class will be referred to as "the groupmate" hereafter. To measure students' academic self-concept in physiology relative to the groupmate, we asked

students to name the student whom they worked with most closely in class and to indicate whether they were smarter or less smart than this person in the context of physiology. Students also reported whether they participated more than, less than, or the same as the groupmate during peer discussions about physiology. On the survey, students responded to an open-ended question about how they determine whether they are more or less smart than another student in the physiology course. Surveys were vetted for face-validity using a think aloud interview protocol (Collins, 2003).

This study was approved by an IRB from Arizona State University.

DATA ANALYSIS

Studies have shown that student demographic characteristics can influence student academic self-concept as well as their experiences in active-learning biology courses (Cokley, 2002; Katelyn M. Cooper & Brownell, 2016a; DeFreitas, 2013; Eddy, Brownell, & Wenderoth, 2014b; Khalaila, 2015; Nagy et al., 2006). After reviewing the prior literature on student academic self-concept and the influence of different characteristics on student experiences in active learning classrooms, we hypothesized that student level factors such as gender (a factor with two levels: female and male), race/ethnicity (a factor with three levels: white, Asian, and underrepresented racial or ethnic minority (URM)), whether a student is a native English speaker (a factor with two levels: native English speaker, non-native English speaker), whether the students transferred to the institution from a 2 year college (a factor with two levels: transfer and non-transfer), and whether the students struggled with an anxiety disorder (a factor with two levels: anxiety and no anxiety) could influence student academic self-concept in physiology relative to the whole class or their groupmate.

General statistical approach: Model selection. The research questions in this paper are exploratory and we identified multiple student-level factors (gender, race/ethnicity, native language, transfer student status, and anxiety level) that may influence student academic self-concept. However, we did not have hypotheses about which of these factors would be most important in predicting student academic self-concept in physiology relative to the whole class or relative to their groupmate. Therefore, we used model selection as our statistical approach because null-hypothesis testing is not appropriate (Burnham & Anderson, 2003; Eddy, Brownell, et al., 2015b). Using model selection approach, we began with a full model that included all predictor variables (e.g. student gender, race/ethnicity, transfer status, anxiety status) and using Akaike's information criterion corrected for small sample sizes (AICc) we determined the best model by selecting the model with the lowest AICc. The best models were used for both analyses. Model-selection analyses were implemented in R using the MuMIn package (Barton et al., 2015). We present the best model for each research question in the results section.

RESEARCH QUESTION 1: TO WHAT EXTENT DO STUDENT CHARACTERISTICS PREDICT STUDENT ACADEMIC SELF-CONCEPT IN PHYSIOLOGY RELATIVE TO THE WHOLE CLASS?

To identify student characteristics that best predict students' academic self-concept in physiology relative to the class as a whole we used a model-selection approach paired with linear regression. Linear regression is a linear approach for modeling the relationship between a linear dependent variable- in this case, the percent of classmates a student perceives they are smarter than- and explanatory variables (e.g. student gender,

race/ethnicity, transfer status, anxiety status). We included all student demographics that we hypothesized might contribute to student academic self-concept as predictors (i.e. explanatory variables) and controlled for students' academic ability by including students' prior grade point averages (GPAs) (Jansen et al., 2014). The full model that was tested is: Percent of classmates a student perceives they are smarter than ~ prior GPA + gender + race/ethnicity + transfer status + native language + anxiety. We used the highest ranked linear model to identify significant variables and predict the percentage of classmates that the average student perceives they are smarter than.

RESEARCH QUESTION 2: TO WHAT EXTENT DO STUDENT CHARACTERISTICS PREDICT STUDENT ACADEMIC SELF-CONCEPT WITH RELATIVE TO THEIR GROUPMATE?

To identify student characteristics that best predict students' academic self-concept relative to their groupmate, we used a model selection approach paired with logistic regression. Logistic regression is an approach for modeling the relationship between a dependent variable that is categorical- in this case, whether a student perceived they were smarter than their groupmate- and explanatory variables such as student gender. The logistic regression model can be used to estimate the probability of whether a student would perceive they were smarter than their groupmate based on predictor variables (e.g. student gender). In our original model we wanted to include the difference between the two groupmate's GPAs as a predictor variable, so we calculated the difference between the two students' GPAs by subtracting the GPA of the groupmate from the GPA of the student (prior GPA difference) and included this in the model as a rough control for the actual academic difference between two students. The full model

that was tested is: Whether a student perceives they are smarter than their groupmate (Y/N) ~ prior GPA difference + gender + race/ethnicity + transfer status + native language + anxiety. We used the highest ranked logistic model to identify significant variables and predict whether the average student perceives they are smarter than the groupmate.

RESEARCH QUESTION 3: HOW DO STUDENTS DETERMINE THEIR ACADEMIC SELF-CONCEPT RELEATIVE TO THEIR GROUPMATE?

Constant comparative methods were used by two authors (AK and KC) to identify themes from a subset of student responses to the question "How do you determine whether you think you are more or less smart than another student?" (Glaser, 1965). Specifically, quotes that were assigned to themes were gathered together and compared to one another throughout the analysis to ensure that the description of the theme represented all quotes within the same group. This iterative comparison ensures that the quotes were not different enough to create a separate category (C Glesne & Peshkin, 1992a). The two authors created a coding rubric and one author (AK) coded a subset of 50 student responses. To establish that the coding scheme was reliable and could be used to replicate the results by other researchers, another author (SB) independently coded the same subset of responses and the two results were compared. The authors had a consensus estimate of 96%. One author (AK) coded the remaining student responses.

RESEARCH QUESTION 4: TO WHAT EXTENT DOES STUDENT ACADMEIC SELF-CONCEPT PREDICT SELF-REPORTED STUDENT PARTICIPATION IN AN ACTIVE LEARNING PHYSIOLOGY CLASS?

We used multinomial regression to identify whether student academic self-concept in physiology relative to their groupmate predicted the amount that the student contributes to in-class peer discussions with the groupmate. Multinomial logistic regression is an approach for modeling the relationship between a categorically distributed dependent variable- in this case, whether a student perceives that they participate more than, less than, or as much as their groupmate- and a predictor variable – whether a student perceives they are smarter than their groupmate. Student self-reported participation with regard to their groupmate had three levels: participates more than groupmate, participates equal to groupmate, and participates less than groupmate. The full model that was tested is: Participation (participates more than groupmate/ participates equal to groupmate /participates less than groupmate) ~ whether a student perceives they are smarter than their groupmate.

RESULTS

Of the 202 students with a complete data set, 130 were female (64.4%), 70 were male (34.7%), and two students identified as other (0.9%). There were 27 students who identified as Asian (13.4%), 111 students who identified as white (55.0%), 44 students who identified as Latino/a (21.8%), eight students who identified as Black or African American (4%) and two students identified as American Indian or Alaska Native (1%). Ten students declined to state their race/ethnicity (5%). The GPA range for the students was 1.9 – 4.0, and the average GPA was 3.35. One hundred and seventy-one students identified as native English speakers (84.7%) and 31 students identified a native language other than English (non-native English speaker) (15.3%). Thirty-eight students (18.8%) indicated that they transferred to the institution from a 2-year institution (transfer

students), 20 students (9.9%) transferred to the institution from a 4-year institution, 134 students (66.3%) started their academic career at the institution (non-transfer students), and for 10 students (5.0%), none of these described their experience. Ninety-two students (45.5%) said they did not struggle with an anxiety disorder, 81 students (40.1%) said they did struggle with an anxiety disorder, and 29 (14.4%) students declined to state.

RESEARCH QUESTION 1: GENDER AND NATIVE LANGUAGE PREDICT STUDENT ACADEMIC SELF-CONCEPT IN PHYSIOLOGY RELATIVE TO THE WHOLE CLASS

The best model for predicting students' academic self-concept in physiology relative to the whole class contained student prior GPA, gender, native language and whether the student struggled with anxiety. Students' prior GPA ($p < .001$), gender ($p < .001$), and native language ($p < .01$) were significant predictors of a student's academic self-concept in physiology relative to the whole class (Table 3.1). On average, males were significantly more likely than females to have a higher academic self-concept in physiology relative to the whole class. Using the best model and controlling for all other variables, the average male with a 3.3 GPA (average GPA of students in the class) is predicted to perceive that he is smarter than 66% of students in the physiology class, while the average female with a 3.3 GPA is predicted to perceive that she is smarter than only 54% of the students in the physiology class (Figure 3.1A).

Table 3.1

Linear Regression Coefficients for the Best Model that Predicts the Percentage of Physiology Classmates that a Student Perceives They are Smarter Than

	Intercept	GPA:	Gender:	Native language:	Anxiety:
Percentage of classmates student perceives they are smarter than			Female (ref: Male)	Not English (ref: English)	Anxiety (ref: No anxiety)
	β±SE (p-value)	β±SE (p-value)	β±SE (p-value)	β±SE (p-value)	β±SE (p-value)
	29.1±13.2 (0.05)*	12.9±3.67 (0.001)***	-11.6±4.11 (0.001) ***	-14.7±4.98 (0.01) **	-6.46±4.03 (0.112)

Note. Model: Percent of classmates student perceives they are smarter than ~ prior GPA + gender + native language + anxiety. Prior GPA, gender, and native language significantly predict the percentage of physiology classmates that a student perceives they are smarter than. A positive number indicates the student is more likely to perceive they are smarter than a higher percentage of physiology classmates. *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$, $^{+}$ $p \leq 0.1$

Figure 3.1. Percentage of Physiology Classmates that the Average Student Perceives They Are Smarter Than

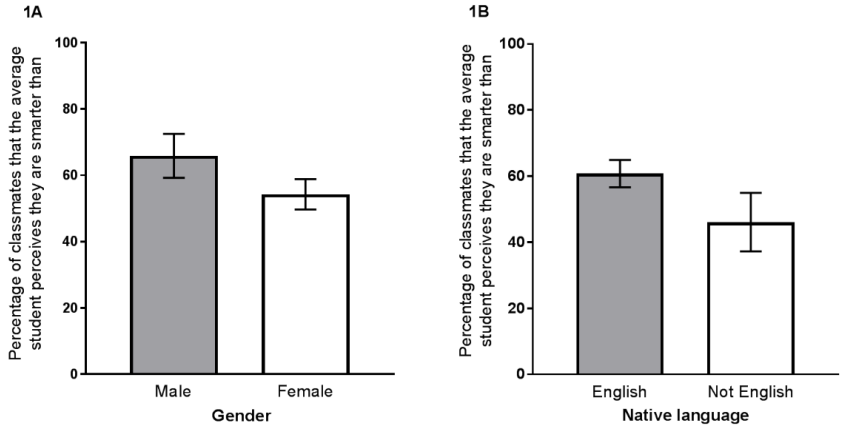


Figure 3.1. Predictions based on top ranked model (Percent of classmates student perceives they are smarter than ~ prior GPA + gender + native language + anxiety). (A) Controlling for all other variables, the average male with a 3.3 GPA perceives that he is smarter than 66% of the class, and the average female with a 3.3 GPA perceives that she is smarter than 54% of the class. (B) Controlling for all other variables, the average native English speaker with a 3.3 GPA perceives they are smarter than 61% of the class, while a non-Native English speaker with a 3.3 GPA perceives they are smarter than 46% of the class.

Students whose native language is English were significantly more likely than students whose native language is not English to have higher academic self-concept in

physiology relative to the whole class. Using the best model and controlling for all other variables, an average student whose native language is English is predicted to perceive that they are smarter than 61% of their physiology classmates, however an average student whose native language is not English is predicted to perceive that they are smarter than only 46% of their classmates (Figure 3.1B**).**

Unsurprisingly, our control variable for students' academic ability, prior GPA, was also a significant predictor of a students' perceived ability in physiology. For every 0.1 increase in a student's GPA, a student was likely to perceive that they were smarter than an additional 1.3% of the class.

RESEARCH QUESTION 2: GENDER PREDICTS STUDENT ACADEMIC SELF-CONCEPT IN PHYSIOLOGY RELATIVE TO THEIR GROUPMATE

The best model to predict whether a student perceives they are smarter than their groupmate included the difference between students' prior GPAs, gender, and transfer status. A student's gender ($p < 0.05$) was a significant predictor of a student's academic self-concept in physiology relative to their groupmate (Table 3.2). Males were more likely than females to have higher academic self-concept in physiology relative to their groupmate. Controlling for all other variables including the difference in academic ability between the student and the groupmate, males are 3.2 times more likely than females to perceive they are smarter than their groupmate. Using predictions from the best model and controlling for all other variables, the average male has a 61% chance of perceiving that he is smarter than his groupmate, while the average female only has a 33% chance of perceiving that she is smarter than her groupmate (**Figure 3.2**).

Table 3.2

Logistic Regression Coefficients for the Best Model that Predicts Whether a Student Perceives That They Are Smarter Than Their Groupmate

Student perceives they are smarter than their groupmate	**Intercept** β±SE (p-value)	**GPA difference:** β±SE (p-value)	**Gender: Female (ref: Male)** β±SE (p-value)	**Transfer student status: Transfer student (ref: Non-transfer student)** β±SE (p-value)
	0.66±0.41 (0.11)	0.58±0.35 (0.09) ⁺	-1.15±0.49 (0.02) *	-0.198±0.563 (0.12)

Note. Model: Whether student perceives they are smarter than their groupmate (Y/N) ~ GPA difference + gender + transfer status. Students' gender significantly predicts whether a student perceives they are smarter than their groupmate. The GPA difference between the two students is a nearly significant predictor. A positive number indicates the student is more likely to perceive they are smarter than their groupmate. *** p≤ 0.001, p≤ 0.01, * p≤ 0.05, ⁺ p≤ 0.1

Figure 3.2. Percent Chance That the Average Student Perceives They are Smarter Than Their Groupmate, Differing Only in Gender

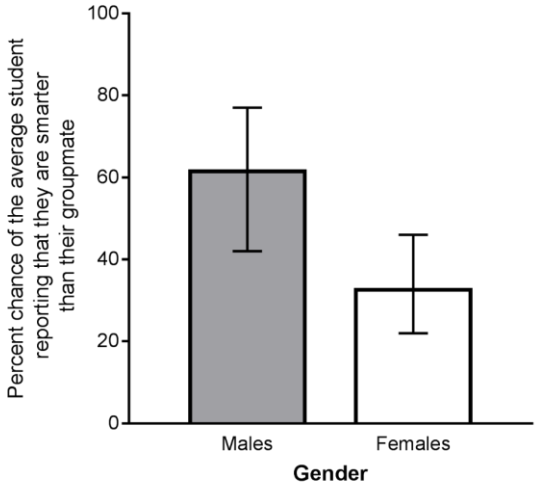


Figure 3.2. Percent chance and 95% CI that the average student perceives they are smarter their groupmate, differing only in gender. Predictions based on top ranked model (Whether student perceives they are smarter than their groupmate (Y/N) ~ GPA difference + gender + transfer status). Controlling for all other variables, the average male has a 61% chance and the average female has a 33% chance that they will perceive that they are smarter than their groupmate

RESEARCH QUESTION 3: HOW STUDENTS ANSWER QUESTIONS DURING CLASS AND PERCEPTIONS OF OTHER STUDENTS' UNDERSTANDING OF PHYSIOLOGY INFLUENCE STUDENT ACADEMIC SELF-CONCEPT RELATIVE TO THEIR GROUPMATE

In order to understand what factors contribute to students' academic self-concept relative to their groupmate, we asked students to respond to an open-ended question asking how they determined whether they were more or less smart than another student. There were 180 students who provided a response to this question (94.7% of students who reported working regularly with at least one other students during the physiology class). We used constant comparison methods to code student responses, which generated nine factors that were mentioned by at least 3% of students (Glaser, 1965). We chose 3% as a cut-off for reporting results because that meant that at least 5 students made a statement that fell into that particular theme. We wanted to be as inclusive as possible in our initial category formation due to the exploratory nature of this work. Because students were able to write as much as they wanted in response to the open-ended question, some students mentioned multiple reasons. However, students were not instructed to make an exhaustive list, so it is likely that we are underestimating the number of students who consider a particular factor when deciding whether they were smarter or less smart than another student in the context of physiology.

We identified nine factors that influenced student academic self-concept in physiology relative to their groupmate (Table 3.3). The most common factor that students reported that influenced their academic self-concept in physiology was who answered more questions correctly (30.6% of student responses). The next most

frequently mentioned factor that influenced students' academic self-concept was who was perceived to have a better understanding of the material or more knowledge about physiology (28.3%). Additionally, students mentioned who was better at reasoning through a problem (9.4%), who provided new insight or new ideas during discussion (8.9%), who grasps material most quickly (7.2%), and who had better communication skills (3.9%) as factors they considered when determining who was smarter. Students also considered the role that students adopted during group work when determining who was smarter. Nearly 8% of students thought that a student was smarter if they took on a teacher role in the group and explained content to other students and a small percentage of students indicated that a student was smarter if they dominated the conversation during group work (5.0%). Students also considered which student put more effort into class by reading or studying material (4.4%). Interestingly, a small subset of students (3.3%) stated that they generally assume they are either smarter or less smart than the people the work with during class.

Because we found that males were more likely than females to have a higher academic self-concept in physiology relative to their groupmate, we were interested in whether males and females consider different factors when evaluating whether they are smarter than their groupmate. We found no significant differences between the percent of males and females who described specific factors that influence whether they perceive they are smarter than their groupmate.

Table 3.3

Descriptions of Factors That Influence Whether a Student Perceives They are Smarter or Less Smart Than Their Groupmate, Percentage of Students That Reported Each Factor, and Example Student Quotes

Factor	Description of factor	% of students who provided factor	Example student quote
Who answers more questions correctly	The smarter student answers more questions correctly, usually with regard to clicker questions or worksheets during class.	30.6%	"By whether or not I'm able to answer more clicker questions accurately."
Who has a better understanding of the material	The smarter student is more knowledgeable, has a better understanding of the content, and/or is better at applying content knowledge	28.3%	"I base it off of how well the person knows the information and how easily they seem to grasp the concepts introduced in class."
Who is better at reasoning through a problem	The smarter student is able to reason through a question better, think more critically, or approach issues or questions more logically.	9.4%	"On how well they reason through their answers. Some are very logical and thoughtful while some are content with simply guessing based on key words or phrases."
Who provides new insights	The smarter student provides new insight, a new idea or a new line of thinking, to the discussion.	8.9%	"Whether the person can think outside of the box and provide more insight than I can."
Who takes on a teacher role	The smarter student answers questions of the other group member, gives other group member help, or guides them to the right answer.	7.8%	"When we share answers, she guides me to the right thinking."
Who grasps material fastest	The smarter student understands the material introduced in class more quickly.	7.2%	"How quickly they pick up on the ideas and concepts in comparison to myself."
Who leads discussion	The smarter student answers the question first, talks first, talks for the majority of the time, or the group member is	5.0%	“When we are discussing, they are the ones that explain and talk the majority of the time.”

	said to dominate or lead the discussion.		
Who puts more effort in	The smarter student spends more time studying or reading, spends more time on the subject outside of class, or takes better notes during class.	4.4%	"I am less smart than they are during class because they do more notes and readings than I do."
Who has better communication skills	The smarter student is more articulate, has better communication skills or is more confident when presenting their ideas.	3.9%	"I determine whether I think they are smarter than me by their confidence level when they explain their reason to their answer."
General assumption about who is smarter	The student states that they always assume that they are smarter or less smart than people they work with.	3.3%	"I always consider people around me smarter than I am."

RESEARCH QUESTION 4: A STUDENT'S ACADEMIC SELF-CONCEPT IN PHYSIOLOGY RELATIVE TO THEIR GROUPMATE SIGNIFICNATLY PREDICTS PARTICIPATION IN PEER DISCUSSION

Students' academic self-concept in physiology relative to their groupmate significantly predicted their self-reported participation in group discussions relative to this person. About one-half of the students reported that during small group discussions about physiology they participated an equal amount as their groupmate (103 of the 190 students who reported working regularly with at least one other student). However, students who perceive they are smarter than their groupmate are 3.22 times more likely to self-report that they participate more than their groupmate than students who perceive they are less smart than their groupmate ($p = .0001$) (Table 3.4). Further, students who perceive they are less smart than their groupmate are 2.36 times more likely to report that

they participate less than their groupmate than students who participate more than their groupmate ($p = .0001$) (Table 3.4).

Table 3.4

Multinomial Regression Coefficients for Model Used to Determine Whether Student Academic Self-Concept in Physiology Relative to their Groupmate Predicts Self-Reported Participation in Peer Discussion with Groupmate

Student level of participation in peer discussion with groupmate	Intercept β±SE (p-value)	Perception of intelligence Student perceives he/she is smarter than groupmate (ref: Student perceives he/she is less smart than groupmate) β±SE (p-value)
Participates less (participates equal)	-0.60±0.24 (0.05)*	-1.17±0.47 (0.001)***
Participates more (participates equal)	-1.5±0.33 (0.05)*	0.86±0.43 (0.001)***

Note. Model: Participation (participates more than groupmate, participates the same as groupmate, participates less than groupmate) ~ whether student perceives they are smarter than their partner (Y/N). Student academic self-concept in physiology with regard to their groupmate predicts student self-reported participation in peer discussion with their groupmate. . *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$, ⁺ $p \leq 0.1$

DISCUSSION

In this study we explored academic self-concept in the context of an undergraduate physiology course. This study is the first to our knowledge exploring the construct of academic self-concept in the context of an active learning undergraduate biology classroom. Active learning classrooms increase the number of interactions between students, so students have more opportunities to compare themselves to other students. According to the Internal/External Frame-of-Reference model, a student's academic self-concept in physiology can be influenced by the students' internal

comparisons or how they perceive their ability in physiology compared to their ability in another domain, as well as their external comparisons or how an individual compares himself/herself to others in physiology. In active learning classrooms, student characteristics have been shown to influence student experiences, particularly their experiences with other students (Cooper & Brownell, 2016a; Eddy, Brownell, et al., 2015b). As such, we predicted that a student's academic self-concept in an active learning physiology course may be influenced by students' characteristics.

We explored academic self-concept in two ways: relative to the whole class and relative to a student's groupmate- the person that the student worked most closely with in class. We found that males and native English speakers had higher academic self-concept relative to the whole class compared with females and non-native English speakers. We also found that males had higher academic self-concept relative to their groupmate compared to females. These differences were observed even when we controlled for other aspects of the students, such as prior academic ability, that have been shown to influence academic self-concept. While we do not know exactly what is causing a difference in academic self-concept between these groups of students, we can speculate based in part on our findings for what students use to estimate whether someone is smart. Students used the interactions in class as a proxy for determining whether another student was smarter than them. They highlighted specific aspects of the active learning classroom, including answering clicker questions and who takes on leadership roles when working in a group, as providing opportunities for them to evaluate their peers. However, there were no significant differences between females and males in the factors that they used to determine whether another student was smarter than them.

We interpret this to mean that males and females are using the same factors to determine other students' intelligence, but females may be judging their own behavior or ability more harshly than males. For example, both males and females are determining whether a student is more intelligent by judging who has a better understanding of the material, but females are more likely to underestimate their own understanding.

The common finding across both types of academic self-concept was that males had higher academic self-concept, even after controlling for prior academic ability. This echoes what has been previously shown in the literature; a review of nearly 20 published papers on self-estimated intelligence concluded that males rate themselves higher than females on self-estimated intelligence, and the greatest gender difference is in mathematical and spatial intelligence (Furnham, 2001). Further, high school males have been shown to have higher academic self-concept than females in both physics and chemistry (Jansen et al., 2014). However, to our knowledge no studies have explored the relationship between gender and students' perception of their intelligence compared with other students in the context of undergraduate physiology. One recent study in an active learning undergraduate biology course explored student perceptions of which of their peers in class knew the course material best and found gender biases: males are more likely to be named by peers as knowledgeable even when controlling for class performance and outspokenness in class (Grunspan et al., 2016a). However, this study did not explore how students perceived their own knowledge of the material, and how the perception of their own knowledge compared with their perceptions of others' knowledge. Of note, the active learning class where our study took place did not involve any whole class discussion (i.e. no single student voices were heard in front of the whole

class), so we would predict that students mostly used interactions in small group peer discussions to form their academic self-concept relative to other students. Another study exploring group dynamics in undergraduate biology classrooms found that during small group discussion males were more likely to prefer a leader/explainer role than females (Eddy, Brownell, et al., 2015b), which may explain why males are more likely to perceive they are smarter. When we asked students how they determined whether they were smarter or less smart than another student in class, whether a student adopts a teaching role and whether a student leads the discussion were both factors that emerged from student responses, which aligns with this previous study. However, more research needs to be done to further explore the impact of these factors on students' perception of their own intelligence and the intelligence of their groupmates.

To our knowledge, our study is the first to document differences in academic self-concept in non-native English speakers compared to native English speakers. Prior research on the experience of non-native English speakers in undergraduate and graduate classrooms typically has been focused on the silence or lack of active participation of non-native English speakers (Fletcher & Stren, 1989; Kao & Gansneder, 1995), but few studies have explored what may contribute to students' silence. A case-study of non-native English speaking graduate students studying in the US found that non-native English speaking students are sometimes silent because they feel that their language abilities and content knowledge are insufficient to express themselves clearly (Tatar, 2005). However, this case-study probing the experiences of non-native English speakers did not explore how students perceive themselves relative to other students in the classroom. Documenting the experiences of non-native English speaking students is the

important first step for instructors to begin to consider how they may disrupt these inequities through inclusive active learning teaching practices (Trujillo & Tanner, 2014).

Why does academic self-concept matter? We found that students with higher academic self-concept are more likely to report participating more in small group discussions; this could have implications for student learning because studies have shown that greater participation can lead to greater learning since students are constructing their own knowledge rather than listening passively (M. T. H. Chi & Wylie, 2014). We may need to explore ways to increase student academic self-concept if we want to increase students' voluntary participation and their subsequent learning. Alternatively, it may mean that we as instructors may need to structure participation so it happens more equitably, regardless of academic self-concept. For example, instructors could assign an "equity monitor" during group discussion whose responsibility it is to make sure that each person in the group gets a chance to contribute (2, 37). Future studies may want to explore the extent to which academic self-concept is malleable and to what extent instructor behavior or course structure could influence it. Further, future studies should explore actual student participation as opposed to self-reported participation to further examine the influence of academic self-concept on student behavior in class.

LIMITATIONS

This study was done in one physiology classroom at one institution with a specific student population. Future studies should explore the influence of student characteristics on academic self-concept in other settings. Additionally, students self-reported their participation with regard to their groupmate; the actual level of participation could be different than what the student perceives. Further, reporting out how smart you feel

compared with another person may cause students to answer the question in a socially desirable way, although 32.7% of the students admitted to perceiving themselves as smarter than their partner and 71.3% perceived they were smarter than at least 50% of students in the whole class.

CONCLUSIONS

In exploring student academic self-concept, we found that males and native English speakers had significantly higher academic self-concept relative to the whole class compared with females and non-native English speakers, respectively. We also found that males had significantly higher academic self-concept relative to their groupmate compared with females. Students identified aspects of active learning that impacted their perception of academic self-concept. Finally, we found that students were more likely to report participating less than their groupmate if they had a lower academic self-concept.

ACKNOWLEDGEMENTS

We would like to thank Yi Zheng and Sarah Eddy for their advice on the statistical analyses. We would also like to acknowledge Michael Ashley for his help with preparation of figures as well as Liz Barnes, Jacquie Cala, and the other members of the Biology Education Research Lab for their thoughtful feedback on this work.

REFERENCES

Adedokun, O. A., Bessenbacher, A. B., Parker, L. C., Kirkham, L. L., & Burgess, W. D. (2013). Research skills and STEM undergraduate research students' aspirations for research careers: Mediating effects of research self-efficacy. *Journal of Research in Science Teaching*, *50*(8), 940–951. https://doi.org/10.1002/tea.21102

Barton, A., Beattie, M., Borissov, G., Bouhova-Thacker, E., Dearnaley, W., Fox, H., … Wharton, A. (2015). Search for the Standard Model Higgs boson produced in

association with top quarks and decaying into bb in pp collisions at √s =8TeV with the ATLAS detector. *European Physical Journal C: Particles and Fields*, *75*. Retrieved from http://dx.doi.org/10.1140/epjc/s10052-015-3543-1

Bong, M., & Skaalvik, E. M. (2003). Academic Self-Concept and Self-Efficacy: How Different Are They Really? *Educational Psychology Review*, *15*(1), 1–40. https://doi.org/10.1023/A:1021302408382

Brunner, M., Keller, U., Hornung, C., Reichert, M., & Martin, R. (2009). The cross-cultural generalizability of a new structural model of academic self-concepts. *Learning and Individual Differences*, *19*(4), 387–403. https://doi.org/10.1016/j.lindif.2008.11.008

Burnham, K. P., & Anderson, D. R. (2003). *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*. Springer Science & Business Media.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Chi, M. T. H., & Wylie, R. (2014). The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes: Educational Psychologist: Vol 49, No 4. *Educational Psychologist*, *49*(4), 219–243.

Cokley, K. O. (2002). Ethnicity, gender and academic self-concept: A preliminary examination of academic disidentification and implications for psychologists. *Cultural Diversity and Ethnic Minority Psychology*, *8*(4), 378–388. https://doi.org/10.1037/1099-9809.8.4.379

Collins, D. (2003). Pretesting survey instruments: An overview of cognitive methods | SpringerLink. *Quality of Life Research*, *12*(3), 229–238.

Cooper, K. M., & Brownell, S. E. (2016). Coming Out in Class: Challenges and Benefits of Active Learning in a Biology Classroom for LGBTQIA Students. *CBE-Life Sciences Education*, *15*(3), ar37. https://doi.org/10.1187/cbe.16-01-0074

Cooper, K. M., Soneral, P. A. G., & Brownell, S. E. (n.d.). Define your goals before you design a cure: a call to use backward design in planning course-based undergraduate research experiences. https://doi.org/doi:10.1128/jmbe.v18i2.1287

Corwin, L. A., Graham, M. J., & Dolan, E. L. (2015). Modeling Course-Based Undergraduate Research Experiences: An Agenda for Future Research and Evaluation. *CBE-Life Sciences Education*, *14*(1), es1. https://doi.org/10.1187/cbe.14-10-0167

DeFreitas, S. C. (2013). Academic Achievement in First Generation College Students: The Role of Academic Self-Concept. *Journal of the Scholarship of Teaching and Learning*, *13*(1), 57–67.

Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering. (2012). The National Academies of

Sciences, Engineering and Medicine. Retrieved from https://doi.org/10.17226/13362

Eddy, S. L., Brownell, S. E., Thummaphan, P., Lan, M.-C., & Wenderoth, M. P. (2015). Caution, Student Experience May Vary: Social Identities Impact a Student's Experience in Peer Discussions. *CBE-Life Sciences Education*, *14*(4), ar45. https://doi.org/10.1187/cbe.15-05-0108

Eddy, S. L., Brownell, S. E., & Wenderoth, M. P. (2014). Gender Gaps in Achievement and Participation in Multiple Introductory Biology Classrooms. *CBE-Life Sciences Education*, *13*(3), 478–492. https://doi.org/10.1187/cbe.13-10-0204

Ferla, J., Valcke, M., & Cai, Y. (2009). Academic self-efficacy and academic self-concept: Reconsidering structural relationships. *Learning and Individual Differences*, *19*(4), 499–505. https://doi.org/10.1016/j.lindif.2009.05.004

Fletcher, J., & Stren, R. (1989). Language Skills and Adaptation: A Study of Foreign Students in a Canadian University: Curriculum Inquiry: Vol 19, No 3. *Curriculum Inquiry*, *19*, 294–308.

Furnham, A. (2001). Self-estimates of intelligence: culture and gender difference in self and other estimates of both general (g) and multiple intelligences. *Personality and Individual Differences*, *31*(8), 1381–1405.

Glaser, B. G. (1965). The Constant Comparative Method of Qualitative Analysis. *Social Problems*, *12*(4), 436–445. https://doi.org/10.2307/798843

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction*. White Plains, NY: Longman.

Grunspan, D. Z., Eddy, S. L., Brownell, S. E., Wiggins, B. L., Crowe, A. J., & Goodreau, S. M. (2016). Males Under-Estimate Academic Performance of Their Female Peers in Undergraduate Biology Classrooms. *PLOS ONE*, *11*(2), e0148405. https://doi.org/10.1371/journal.pone.0148405

Guay, F., Ratelle, C. F., Roy, A., & Litalien, D. (2010). Academic self-concept, autonomous academic motivation, and academic achievement: Mediating and additive effects. *Learning and Individual Differences*, *20*(6), 644–653. https://doi.org/10.1016/j.lindif.2010.08.001

Jansen, M., Schroeders, U., & Lüdtke, O. (2014). Academic self-concept in science: Multidimensionality, relations to achievement measures, and gender differences. *Learning and Individual Differences*, *30*, 11–21. https://doi.org/10.1016/j.lindif.2013.12.003

Johnson, A. C. (2007). Unintended Consequences: How Science Professors Discourage Women of Color. *Science Education*, *91*, 805–821. https://doi.org/10.1002/sce.20208

Kao, C., & Gansneder, B. (1995). An assessment of class participation by international graduate students. *Journal of College Student Development*, *36*(2), 132–140.

Khalaila, R. (2015). The relationship between academic self-concept, intrinsic motivation, test anxiety, and academic achievement among nursing students: Mediating and moderating effects. *Nurse Education Today*, *35*(3), 432–438. https://doi.org/10.1016/j.nedt.2014.11.001

Marsh, H. W., & Craven, R. (1997). Academic Self-Concept: Beyond the Dustbowl. In *Phye G. (Ed.), Handbook of classroom assessment: Learning, achievement, and adjustment* (pp. 131–198). Orlando, FL: Academic Press. Retrieved from https://scholar.google.com/scholar_lookup?publication_year=1997&pages=131-198&author=H.W.+Marsh&author=R.+Cravenauthor=G.+Phye&title=Handbook+of+classroom+assessment:+Learning,+achievement,+and+adjustment

Nagy, G., Trautwein, U., Baumert, J., Köller, O., & Garrett, J. (2006). Gender and course selection in upper secondary education: Effects of academic self-concept and intrinsic value. *Educational Research and Evaluation*, *12*(4), 323–345. https://doi.org/10.1080/13803610600765687

Ommundsen, Y., Haugen, R., & Lund, T. (2005). Academic Self-concept, Implicit Theories of Ability, and Self-regulation Strategies. *Scandinavian Journal of Educational Research*, *49*(5), 461–474. https://doi.org/10.1080/00313830500267838

Ong, M., Wright, C., Espinosa, L., & Orfield, G. (2011). Inside the Double Bind: A Synthesis of Empirical Research on Undergraduate and Graduate Women of Color in Science, Technology, Engineering, and Mathematics. *Harvard Educational Review*, *81*(2), 172–209. https://doi.org/10.17763/haer.81.2.t022245n7x4752v2

Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-Concept: Validation of Construct Interpretations. *Review of Educational Research*, *46*(3), 407–441. https://doi.org/10.3102/00346543046003407

Smith, J. L., Lewis, K. L., Hawthorne, L., & Hodges, S. D. (2013). When Trying Hard Isn't Natural: Women's Belonging With and Motivation for Male-Dominated STEM Fields As a Function of Effort Expenditure Concerns. *Personality and Social Psychology Bulletin*, *39*(2), 131–143. https://doi.org/10.1177/0146167212468332

Tatar, S. (2005). Why Keep Silent? The Classroom Participation Experiences of Non-native-English-speaking Students. *Language and Intercultural Communication*, *5*(3–4), 284–293. https://doi.org/10.1080/14708470508668902

Trujillo, G., & Tanner, K. D. (2014). Considering the Role of Affect in Learning: Monitoring Students' Self-Efficacy, Sense of Belonging, and Science Identity. *CBE-Life Sciences Education*, *13*(1), 6–15. https://doi.org/10.1187/cbe.13-12-0241

Uitto, A. (2014). Interest, attitudes and self-efficacy beliefs explaining upper-secondary school students' orientation towards biology-related careers. *International Journal of Science and Mathmatics Education*, *12*(6), 1425–1444. https://doi.org/10.1007/s10763-014-9516-2

Vermunt, J. D. (1996). Metacognitive, cognitive and affective aspects of learning styles and strategies: A phenomenographic analysis. *Higher Education*, *31*(1), 25–50. https://doi.org/10.1007/BF00129106

Vision and Change in Undergraduate Biology Education: Chronicling Change, Inspiring the Future. (2015). American Association for the Advancement of Science.

CHAPTER 4

THE INFLUENCE OF ACTIVE LEARNING PRACTICES ON STUDENT ANXIETY IN COLLEGE SCIENCE CLASSROOMS

The prevalence of anxiety is increasing among college-aged students and the negative effect of anxiety on student health and academic performance is a pressing concern for college counseling centers (Center for Collegiate Mental Health, n.d.; Reetz, Krylowicz, & Mistler, 2014). The American College Health Association, which provides the largest known comprehensive dataset on the health of college students, reported that 60.8% of college students felt overwhelming anxiety within the past year and 24.2% of students reported that anxiety negatively affected their academic performance (American College Health Association, 2017).

College in general can be anxiety-inducing because many students experience an increase in academic work load coupled with new responsibilities (Misra & McKean, 2000; Ross, Niebling, & Heckert, 1999) and science classrooms have been reported to be particularly stressful for some students (Hanson, 2008; Koul, Roy, & Lerdpornkulrat, 2012; Udo, Ramsey, & Mallow, 2004). The rigor and difficulty of the subject material of science courses is a common cause of student anxiety (Mallow, 2006; Udo et al., 2004). Further, science courses are known to be generally competitive and can foster "chilly," and even "hostile" environments, which may cause students to experience higher levels of anxiety (Brainard & Carlin, 1998; Seymour & Hewitt, 1997a; Wyer, Barbercheck, Geisman, Ozturk, & Wayne, 2001). Students may also feel anxious in science classes because science faculty have been described as "unapproachable" by students (Seymour & Hewitt, 1997a) and there are often fewer female instructors and instructors of color in

science, which has been hypothesized to increase anxiety for students in minority groups (Mallow, 2006). Finally, many college science classrooms are large enrollment, particularly at the introductory level, which can elevate student anxiety levels because of the large numbers of students (M. E. McKinney, Gatchel, & Paulus, 1983).

High levels of anxiety have been shown to negatively influence student academic experiences in college (W. J. McKeachie, 1984; Vitasari, Wahab, Othman, Herawan, & Sinnadurai, 2010). More specifically, anxiety has been shown to negatively affect student cognitive and affective outcomes (Bostani, Nadri, & Nasab, 2014; W. J. McKeachie, 1984; Vitasari et al., 2010). For example, a study on 106 college students enrolled in a general psychology course showed that anxiety can inhibit exam performance if it cannot be resolved in some way (Wilbert J. McKeachie, 1951). Another study examining anxiety in second year engineering students found that high anxiety led to lower GPAs (Vitasari et al., 2010). Similarly, Culler and Holahan (Culler & Holahan, 1980) explored the relationship between anxiety levels and incoming first-semester students' study habits and performance and found that students with high anxiety had poorer study skills and achieved lower first-semester GPAs than students with low anxiety. Lastly, a recent study found that students with higher general anxiety in biology were more likely to report lower course grades and intent to leave the major than students who report less anxiety (England, Brigati, & Schussler, 2017). While a moderate amount of anxiety has been shown to improve student motivation in some instances (Jun Zhang, 2001), these studies on high levels of student anxiety illustrate how detrimental anxiety can be for student academic success. Given these findings, there is

interest in trying to decrease student anxiety, and identify the factors that lead to higher levels of anxiety, in order to maximize student academic success and retention in science.

College science courses are increasingly being transitioned from traditional lecture to active learning because, on average, active learning has been shown to be a more effective way to teach (Freeman et al., 2014b; Science, 2015). Active learning is a broad umbrella term to describe courses where students are actively constructing their own knowledge as opposed to listening passively. There are many different ways to enact active learning, but typically active learning includes students working with other students during class and more frequent assessment of student learning in the classroom (Eddy, Converse, & Wenderoth, 2015b; Freeman et al., 2014b).

Active learning college science classrooms may be particularly anxiety-inducing for students because of the high frequency of situations that could induce a student's fear of failure. Anxiety has been described as a multifaceted reaction to the threat of failure; the idea of failure can be especially devastating when students put effort into a task because it can imply that they have a low ability or are incompetent, which threatens their self-worth (Covington, 1992). College students often fear failure when their academic ability is evaluated (Stipek, 1993), which has been termed achievement anxiety (Covington, 1992). College students' academic abilities are commonly evaluated by assessing their performance on a task such as a quiz or exam (Covington, 1992; Stipek, 1993); these situations are referred to as evaluative situations. Nearly all college science courses have evaluative situations where student achievement anxiety can be activated; the most common evaluative situations in most college courses are exams (Covington, 1992). However, active learning courses typically have a greater number of evaluative

situations compared to traditional lecture courses because of larger number of assignments and activities during class. Students can experience achievement anxiety when they evaluate their own learning, such as when a student is working on an in-class assignment and realizes that he or she is unable to solve a problem. Students can also experience achievement anxiety when they are evaluated by other students or the instructor. For example, students may experience achievement anxiety when talking with other students about course content during class if they view that discussion as an evaluative situation where their competence is evaluated by others (Stipek, 1993). Similarly, answering a question posed by an instructor can instigate achievement anxiety, especially if the student does not know the correct answer and worries about the instructor's opinion of them. Thus, because active learning classes are structured with high numbers of activities where students could be evaluated, it is likely that active learning courses have a higher potential to increase student anxiety compared to traditional lecture courses.

To our knowledge, no studies have explored students' anxiety in college active-learning courses across science. However, there is some evidence to suggest that students with high levels of anxiety may struggle in active learning courses more than they do in traditional lecture. A study that explored the experiences of 69 junior college students enrolled in either a teacher-centered section or a student-centered section of an introductory psychology course found that students with high levels anxiety performed best in the teacher-centered classroom where the instructor discouraged student participation during class, whereas students with low levels of anxiety performed best in the student-centered classroom where the instructor encouraged student participation

during class (Dowaliby & Schumer, 1973). Similarly, a study in a computer science course found that students with high levels of anxiety performed better in teacher-centered lectures and students with low levels of anxiety performed better in more cooperative, interactive learning (McInerney et al., 1997). While these studies indicate that active learning classes may present challenges for students with high levels of anxiety, they do not explore why students with high levels of anxiety do not perform as well in active learning classes or whether evaluative active learning practices further exacerbate students' high anxiety. However, a recent study across three large-enrollment biology classes showed that five active learning classroom practices (cold call, volunteering to answer questions, completing worksheets in class, working in groups, and using clickers) all caused students to experience anxiety (England et al., 2017). However, this study only explored the extent to which these active learning practices caused student anxiety exclusively in biology courses and did not explore whether these active learning practices could be implemented or modified in ways to lessen anxiety.

While the study by England and colleagues (2017) suggests that active learning practices can increase students' anxiety, there is some evidence to suggest that evaluative active learning practices may also decrease students' anxiety. For example, one study of pre-service math teachers found that their anxiety was reduced when learning math through "hands-on" approaches (Harper & Daane, 1998). Interviews with the preservice teachers found that they enjoyed "doing something" compared to listening to lecture and that a hands-on approach to problem solving helped them better understand math, which caused them to feel less anxious. This study also found that the participants' anxiety was reduced when they worked in groups to solve math problems. The participants explained

that their anxiety decreased because they understood the content better when someone besides the instructor explained it to them and that working in groups allowed them to work through problems in more than one way. In another study that explored anxiety levels in 163 high school students in a science class, the researcher found that students who were randomly assigned to work on science problems in groups, as opposed to working through problems individually, expressed significantly lower anxiety (Okebukola, 1986). The author hypothesized that group work reduced students' anxiety because it helped them to focus their attention on science and made them feel more accepted in the classroom. Thus, while active learning practices may increase students' anxiety if students fear being evaluated negatively, the same active learning practices may have the potential to decrease students' anxiety by positively influencing their learning. Yet, to our knowledge, no studies have explicitly explored how active learning practices could have a positive impact on student anxiety. Thus, we aim to explore how and why evaluative situations in active learning courses may increase or decrease student anxiety.

In this study, we explore how evaluative active learning practices affect students' anxiety in the context of large-enrollment science courses. We focused only on evaluative situations that are common in active learning courses; because exams are features of both active learning and traditional lecture courses, we constrained our study and did not include exams. We decided to use an in-depth semi-structured interview approach to explore the nuances of the factors that may influence how active learning practices affect student anxiety in these classes. Individuals have unique levels of enduring anxiety (Turner & Gellman, 2013); that is, some people have consistently mild

levels of anxiety and others have consistently severe levels of anxiety. In this study, we were interested in exploring how an individual's standard anxiety level, regardless of how high or low it was, changed as a result of engaging in active learning practices. Specifically, we set out to identify:

a. What specific aspects of evaluative active learning practices in large-enrollment science courses cause student anxiety to be increased?
b. What specific aspects of evaluative active learning practices in large-enrollment science courses cause student anxiety to be decreased?

METHODS

INTERVIEW RECRUITMENT

In Fall 2016 and Fall 2017 we administered a short demographic survey to students enrolled in large-enrollment active-learning biology courses (Introductory Biology and Upper-level Physiology) at a research-intensive institution in the southwestern United States. In addition to demographic questions, the survey asked students whether they would be willing to be interviewed about their experience in active learning science courses.

We chose to take a purposive sampling approach (Patton, 2002) and recruited students who were enrolled in the large-enrollment active learning biology courses at the end of the semester, so that all students who interviewed had completed at least one active learning science course. Many large-enrollment chemistry courses and some physics courses are also being taught in an active learning way at this institution, so it is likely that students had completed more than one large-enrollment active learning science class at this time. Students were offered a $15 gift card as an incentive to participate in an

interview focused their experience in active learning in science courses for the purpose of improving active learning at their institution. Email recruitments were sent out to 1086 students who had indicated on the demographic survey that they were interested in participating in an interview. Fifty-two students signed up for and came to their interview. The researchers chose to analyze all 52 student interviews and, upon data analysis, were confident that data saturation had been reached and no additional students were recruited.

IDENTIFYING VARYING LEVELS OF ANXIETY IN STUDENTS

All students have likely experienced at least mild levels of anxiety as a normal response to stress (Bamber & Schneider, 2016) and their anxiety levels may fluctuate depending on life stressors ("NIMH » Anxiety Disorders," n.d.). However, for students with chronically high levels of anxiety, alleviating or exacerbating anxiety within the context of a science classroom could be particularly impactful. Thus, we hoped to interview students with a range of anxiety levels.

To get an estimate of students' anxiety levels, we asked all interviewees to fill out the Generalized Anxiety Disorder 7-item scale (GAD-7), which measures anxiety on a continuum (Spitzer, Kroenke, Williams, & Löwe, 2006). The GAD-7 consists of seven Likert-scale questions about symptoms of anxiety with four answer choices ranging from not at all to nearly every day. We used this measure as an approximation for the extent to which each interviewee experienced high anxiety as an enduring personality trait (Turner & Gellman, 2013).

INTERVIEWS

Semi-structured interviews were conducted by two interviewers (K.M.C and V.R.D). We developed a set of interview questions to explore how students' levels of anxiety were affected in active learning large-enrollment college science courses. After developing the interview questions, we conducted think-aloud interviews to establish cognitive validity of the interview questions with four undergraduate students- two whom identified as having chronically high anxiety and two of whom did not. The interview protocol was iteratively revised after each think-aloud interview until no questions were unclear or misinterpreted by students (Trenor, Miller, & Gipson, 2011a). During the interview, we defined active learning by referencing the active learning class that the student was recruited from (e.g. "an active learning class such as BIO 101"). We intentionally did not define active learning by referencing common active learning practices such as clicker questions or small group discussions because we did not want to bias student responses by focusing their attention on specific practices. During the interviews, students were asked to describe what aspects, if any, of their large-enrollment active learning college science courses increased their feelings of anxiousness and why. We also asked students what aspects, if any, decreased their feelings of anxiousness and why. The semi-structured nature of the interviews allowed us to explore interesting topics that emerged in an interview with one student that may not have emerged in every interview. Interviews were audio-recorded and transcribed upon completion. The average interview time was 45 minutes and interviews ranged from 30 minutes to 60 minutes. Data were anonymized and pseudonyms have been given to each of the students. We suspected that students had not previously been asked about how their experience in large-enrollment active learning science courses might influence their

anxiety, so we gave students a handout with some of the interview questions just before the interview began and allowed them ~5 minutes to write down their thoughts about each question. We have previously found that this helps students give more complete answers to interview questions, particularly when the subject that is being explored is stigmatized (Katelyn M. Cooper & Brownell, 2016b). Students were told that they could use the piece of paper as a reference during the interview.

INTERVIEW ANALYSIS

Two researchers (K.M.C. and V.R.D.) reviewed every interview and identified the most prominent active learning practices that were mentioned by students when asked what specific aspects of large-enrollment active-learning science classes influence their feelings of anxiousness. The two researchers identified three practices- clicker questions, group work, and cold call/random call- that were mentioned by at least 50% of students (26 students) during the interviews. We did not ask students specifically about any of these practices, yet these practices emerged from the interviews. We chose to exclusively explore these three active learning practices that emerged in the majority of interviews to maximize the chance that we had interviewed enough students to reach data saturation for each active learning practice. Two researchers (K.M.C. and V.R.D.) independently reviewed half of the interviews (26 interviews each). The researchers separately analyzed each interview transcript for what aspects of each active learning practice- clicker questions, group work, and cold call/random call- increased and/or decreased students' anxiety. For each active learning practice, the researchers allowed themes to emerge from the data and took notes throughout the analysis and reconvened to discuss their findings using constant comparative methods. Specifically, the researchers used

their notes to develop themes and then discussed what quotes from the interviews they reviewed fell under which themes. This constant comparison of quotes was meant to ensure that the description of the theme adequately represented all quotes within the same group and that the quotes were not different enough from one another to warrant a separate theme (Corrine Glesne & Peshkin, 1992a). The researchers determined that there were no themes that were unexplored and that data saturation had been reached within the current sample and no further recruitment was needed (Guest, Bunce, & Johnson, 2006). Together, the researchers developed a coding rubric for what elements of each active learning activity influenced student anxiety levels. The researchers then individually coded all 52 interviews using the coding rubric and then compared their codes. The reviewers came to consensus about any portion of an interview that they had coded differently.

This study was approved by the university's institutional review board.

RESULTS AND DISCUSSION

We present the results and discussion together to help elaborate on our findings and contextualize them with previous literature. We also do not report out specific percentages of students who perceived a practice to increase or decrease their anxiety because we did not ask every student explicitly about how each practice influenced their anxiety and instead allowed students to bring up a particular practice that increased or decreased their anxiety. We did not identify any trends about whether students with differing anxiety levels (minimal, mild, moderate or severe) were more or less likely to report that a specific practice increased or decreased their anxiety. However, we did note that students with minimal anxiety were less likely to mention any of the three active

learning practices that we explored in their interview than students with higher levels of anxiety. We present how each active learning practice affected each of the 52 students that we interviewed in Table 4.1.

STUDENT POPULATION

A demographic profile of each student is reported in Table 4.1. Of the students whom were interviewed, 78.8% were female and 21.2% are male. The majority of students (53.8%) identified as White, 28.8% identified as Hispanic, Latino/a or Spanish, 9.6% identified as Black or African American and 7.7% identified as Asian or as a Pacific Islander. Seventy-three percent of students identified as a continuing generation college student and 26.9% of students identified as a first-generation college student. Students' experience with anxiety varied across our sample. We used the GAD-7 scoring rubric to classify students' level of generalized anxiety (Spitzer et al., 2006). Seventeen percent of students reported minimal generalized anxiety (GAD-7 score < 5), 30.8% of students reported mild generalized anxiety (GAD-7 score 5-9), 28.8% of students reported moderate generalized anxiety (GAD-7 score 10-14), 21.2% reported severe generalized anxiety (GAD-7 score ≥ 15), and one student was unwilling to complete the Generalized Anxiety Disorder Scale.

Table 4.1

Student Demographics and Report of How Active Learning Practices Influence Each Student's Anxiety

Student demographics	Whether a student reported that an active learning practice increased their anxiety, decreased their anxiety, or did not affect their anxiety.

Pseudonym	GAD Score	General anxiety level based on GAD score	Class	Gender	Race/ Ethnicity	First-generation college going	Clicker questions	Group work	Cold call/ Random call
Viviane	2	Minimal	Intro Bio	Female	Asian/ Pacific Islander	No	X	X	–
Felicia	2	Minimal	Upper Bio	Female	Hispanic/ Latino	Yes	–	↑↓	↑
Marcus	3	Minimal	Upper Bio	Male	Black or African American	No	–	–	–
Jessica	3	Minimal	Intro Bio	Female	White	No	↓	–	–
Dawn	3	Minimal	Intro Bio	Female	Asian /Pacific Islander	No	–	↓	–
Bill	4	Minimal	Upper Bio	Male	White	No	–	↓	–
Xavier	4	Minimal	Upper Bio	Male	Black or African American	Yes	–	–	↑
Sally	4	Minimal	Upper Bio	Female	White	No	↑	–	↑
Rodger	4	Minimal	Upper Bio	Male	White	No	↓	↑↓	↑
Kathryn	5	Mild	Upper Bio	Female	White	No	–	↑	–
Craig	5	Mild	Upper Bio	Male	White	No	X	↑	↑
Taylor	5	Mild	Intro Bio	Female	White	No	↑ ↓	↓	↑
Evan	5	Mild	Upper Bio	Male	White	No	X	↓	↑
Lisa	6	Mild	Upper Bio	Female	White	No	X	–	–
Parker	6	Mild	Upper Bio	Other	White	No	↑	↑	↑
Giselle	6	Mild	Upper Bio	Female	Hispanic/ Latino/a	Yes	↑	↑	↑
Rachelle	6	Mild	Upper Bio	Female	Black	Yes	↑	↑	↑
Shannon	6	Mild	Intro Bio	Female	White	No	–	X	↑
Shawna	6	Mild	Intro Bio	Female	Asian/ Pacific Islander	No	–	X	↑
Claire	6	Mild	Upper Bio	Female	Hispanic/ Latino/a	No	X	X	↑
Kenna	6	Mild	Upper Bio	Female	White	No	X	X	↑
Rick	7	Mild	Upper Bio	Male	White	No	↑ ↓	–	–
Mya	7	Mild	Intro Bio	Female	Black or African American	No	–	–	↑
Jordan	7	Mild	Upper Bio	Female	White	No	–	↑	↑

Megan	8	Mild	Intro Bio	Female	White	No	↑	↑	−
Gloria	10	Moderate	Intro Bio	Female	Hispanic/ Latino/a	Yes	↑	↓	−
Carter	10	Moderate	Upper Bio	Male	Black or African American	No	↓	↓	−
Tiffany	11	Moderate	Upper Bio	Female	White	No	↑	↑	−
Anita	11	Moderate	Upper Bio	Female	Hispanic/ Latino/a	No	X	↑	−
Charlotte	11	Moderate	Intro Bio	Female	Hispanic/ Latino/a	No	−	↑	↑
Olivia	11	Moderate	Upper Bio	Female	White	No	↑	↓	↑
Theodore	12	Moderate	Upper Bio	Male	White	No	−	↑	−
Quinn	12	Moderate	Upper Bio	Female	Hispanic/ Latino/a	No	↑↓	↑↓	↑
Serena	12	Moderate	Upper Bio	Female	Hispanic/ Latino/a	Yes	−	↓	↑
Lidia	13	Moderate	Intro Bio	Female	Hispanic/ Latino/a	No	↑↓	↓	↑
Antoinette	14	Moderate	Intro Bio	Female	White	No	↑↓	↓	−
Lindsay	14	Moderate	Intro Bio	Female	White	No	↑	−	↑
Blanca	14	Moderate	Upper Bio	Female	Hispanic/ Latino/a	Yes	−	↑	↑
Celeste	14	Moderate	Upper Bio	Female	Asian/ Pacific Islander	Yes	↓	↓	↑
Cindy	14	Moderate	Upper Bio	Female	White	No	↓	↓	↑
Kit	15	Severe	Intro Bio	Female	White	Yes	↓	↓	−
Emmy	15	Severe	Intro Bio	Female	Hispanic/ Latino/a	No	↑	−	↑
Brittany	15	Severe	Intro Bio	Female	White	No	−	↑	↑
Alana	15	Severe	Intro Bio	Female	Hispanic/ Latino/a	No	↑	↑	↑
Kristen	15	Severe	Intro Bio	Female	White	No	−	X	X
Iris	17	Severe	Upper Bio	Female	Hispanic/ Latino/a	Yes	↑	↑	−
Paige	17	Severe	Upper Bio	Female	White	No	−	↓	↑
Anne	20	Severe	Upper Bio	Female	White	Yes	↑	↓	−
Cole	20	Severe	Upper Bio	Male	Hispanic/ Latino/a	Yes	↑	↑	↑
Morgan	21	Severe	Upper Bio	Female	White	No	↑	↑↓	−
Monya	21	Severe	Upper Bio	Female	Hispanic/ Latino/a	Yes	−	↑↓	−
Owen	NA	NA	Upper Bio	Male	White	Yes	−	−	↑

Note. ↑ indicates that a student highlighted a specific element of an active learning practice that increases their anxiety, ↓ indicates that a student highlighted a specific element of an active learning practice that decreases their anxiety, X

indicates that a student reported that a specific active learning practice does not influence their anxiety levels and – indicates that the student never mentioned the specific active learning practice during their interview.

ACTIVE LEARNING PRACTICE #1: THE INFLUENCE OF CLICKER QUESTIONS ON STUDENT ANXIETY

Clicker questions are often used by instructors as a way to improve student conceptual understanding and to gather immediate feedback from students during class. Instructors typically pose multiple-choice clicker questions to all students during class and students answer anonymously using personal response devices or clickers. Instructors are usually able to immediately interpret the frequency of correct student responses, which instructors can use to inform and adjust their teaching in real time (Sun, Martinez, & Seli, 2014). Because each student has a registered clicker, instructors can also use clickers to promote accountability in class, ranging from giving students participation points for "clicking in" to awarding points only for correct responses.

Using clicker questions during class has been championed as an active learning activity that allows instructors to collect feedback from individual students anonymously and simultaneously, which prevents students from changing their answers to conform to academically higher status students, which can happen when students raise their hand to indicate an answer (Kennedy & Cutts, 2005; Stowell & Nelson, 2007; Sun et al., 2014). Further, clicker questions have been shown to encourage an increase in student engagement (Bode, Drane, Kolikant, & Schuller, 2009; Dallaire, 2011; Stowell & Nelson, 2007; Sun et al., 2014; Trees & Jackson, 2007) and improve academic performance (Anthis, 2011; Elicker & McConnell, 2011; Kennedy & Cutts, 2005; Stowell & Nelson, 2007).

During the interviews, 26 students (50.0%) indicated that clickers influenced their anxiety in some way. We identified specific ways in which clicker questions affect student anxiety, which are summarized in Figure 4.1.

Figure 4.1. Factors That Influence Student Anxiety About Clicker Questions

	Timing	Grading		Understanding of science concepts		Understanding how science knowledge compares to others	
	Student does not have enough time	Points awarded for completion	Points awarded for accuracy	Student confirms what concepts they do/do not understand	Student clarifies understanding	Student realizes other students struggle with concepts	Student realizes they know less than other students
Effect on student anxiety	↑	↓	↑	↓	↓	↓	↑

Figure 4.1. ↑ indicates a factor that increases student anxiety, ↓ indicates that a factor decreases student anxiety.

Timing and grading of clickers. Students identified that their anxiety in science classrooms increased when they felt they did not have enough time to think though a clicker question. For example, Lindsay explained that she feels as if she is a "slow thinker" and can feel rushed during clicker questions, which exacerbates her anxiety.

> Lindsay: Clicker questions are stressful (…) I'm a very slow thinker. I don't know what is wrong with me, but I'm a very, very slow thinker. I'm rushed into things. Being rushed causes me anxiety.

Other students, such as Taylor and Megan, highlighted that clicker questions were particularly anxiety-inducing if they did not feel as though they had enough time to think through the question *and* if points were awarded for correct answers. Students explained that if they did not have enough time to fully engage with the question, it was likely that they would get the question wrong. If getting the question wrong meant that they also lost points, their anxiety was further exacerbated.

Taylor: If [clicker questions] are timed, it causes me to feel anxious. Because [when the question is for points], it's like I need to get something in, and I'm going to get it wrong.

Megan: Clicker questions make me anxious when they're timed. In one of my science classes, my professor would time the clicker questions and the amount of time we have to click in. If there was any material that you had to calculate or something, I didn't always do it in time. I would lose my whole points for that day even though I was in the class and I was present.

Megan went onto describe a positive feedback loop where her increased level of anxiety influenced her ability to think through the clicker question, which in turn further exacerbated her anxiety. She explained that she becomes focused on getting the points as opposed to focusing on learning the content.

Megan: When I feel anxious, it's almost that I can't solve the problem or answer the question clear-mindedly because I'm so scattered and worried about getting my answer in on time (…) I can't think clearly so if I were to click in a question or have an answer, I don't know if my answer was the correct answer because I'm so worried about getting my points that day that I feel that I don't know. I'm not always having the clearest mind.

Students suggested that, when using clickers, instructors could provide points for participating as opposed to points for accuracy, which would reduce their anxiety. However, some studies show that students are likely to learn more, as measured by getting the correct answer more frequently, if instructors reward correct answers with points, likely because it increases student accountability (James, 2006; Willoughby &

Gustafson, 2009). Yet, as Megan's quote suggests, penalizing students who give incorrect answers by not awarding points may encourage students to focus their attention on points instead of focusing their attention on learning. In a study exploring student anxiety in college math, the authors found that students who have goals associated with the desire to achieve favorable grades (performance oriented) are more likely to experience anxiety than students who are most interested in learning and mastering the material (learning-goal oriented) (Ironsmith, Marva, Harju, & Eppler, 2003). Thus, it is possible that by timing clicker questions, instructors are inadvertently shifting students to adopt more performance-oriented attitudes, which may heighten their anxiety. However, we propose that there are ways to implement clicker questions that may reduce anxiety while still increasing student accountability. For example, instructors can pose a clicker question to students and have them answer individually. Then, the instructor can allow students to discuss with their neighbors and answer again. If the instructor grades the first attempt on participation and then the second attempt on accuracy, it improves students' chances that they will get the question correct (Smith et al., 2009) and also allows them to think through the question the first time without the pressure of getting the question correct. However, the instructor would need to make this grading explicit to students or else students may assume that every question is graded on accuracy. We will further discuss the potential benefits of allowing students to work together on clicker questions in the finding about the relationship between student anxiety and group work.

Understanding of science concepts and comparing knowledge with others during clicker questions. We also found that clicker questions can affect student perceptions of their own learning, which influences their anxiety. Students explained that

instructors' use of clicker questions helped them clarify concepts and deepen their understanding of the presented material, which is consistent with prior literature encouraging instructors to integrate clicker questions into the classroom (Knight, Wise, & Southard, 2013; Smith et al., 2009; Smith, Wood, Krauter, & Knight, 2011). Being provided with an opportunity to strengthen their understanding of science seemed to reduce many students' feelings of anxiety. For example, Kit explained how clicker questions help her feel as though she has a more complete understanding of the material, which she perceives to reduce her anxiety.

> Kit: If anything, I feel like the active learning part reduces my anxiety (...) I feel like I have a more complete understanding of the material (…) The clicker questions really helped me feel like I'm getting a more complete understanding of [the material].

Students also explained that even if a clicker question did not help them understand a concept, simply being able to identify what concepts they do and do not understand seemed to lessen their anxiety because then they knew what to focus on when studying. For example, when comparing traditional lecture and active learning science courses, both Celeste and Rodger describe that active learning activities such as clicker questions allow them to identify what they do or do not understand, whereas they do not have the same opportunity to check their understanding in traditional lecture courses.

> Celeste: The active learning, you know what you know by clicker questions, by answering questions, so you know what you understand and what you don't understand. In traditional lecture courses, you're just given the material and [the instructor says] "I'll see you during the test, let's see what you get wrong or right."

Rodger: In the passive learning, in traditional lecture, the anxiety levels are pretty high. It's sort of like a plateau, you kind of plateau at this really high level [of anxiety] because you're trying to jot down information in a notebook for an hour, and then there's no clicker questions or there are no assignments and stuff like that, so you don't know if you actually know that information.

For most students, getting a single clicker question incorrect did not seem to exacerbate their anxiety unless they felt as though they were one of a few students out of the whole class who did not understand the concept. For example, Lindsay and Parker describe what it feels like to be in the minority group of students who get a question incorrect.

Lindsay: I feel anxious when I feel like I am in the wrong science class. For example, when everyone else understands [the concept], and I don't. When [the instructor] puts up that graph [after a clicker questions] and says 'All these people say C, and this majority says D,' or something. I'm usually the B people. In that moment, I'm like, 'How are people understanding it?' I feel so dumb. I don't understand how people get it, and I can't.

Parker: If I really tried on the question and really don't understand the concept and see that on a graph, 90% of the class knows this and I'm in the 10% that got the question wrong. I guess I'm not doing great. Then especially for me, with my anxiety, it can really affect me.

Although displaying a histogram that shows 95% of the class got a question right may be a way to highlight the success of most of the class, we do not know of literature that supports that this is beneficial for students who got the question right. However, these

student interviews suggest that showing that graph may increase anxiety for students who answered the question incorrectly. Based on these interviews, we would recommend instructors not show a histogram when all but a few students selected the correct answer. Alternatively, if an instructor prefers to show the histogram, they may want consider practicing error framing, or framing students' mistakes or misconceptions as natural or useful (Bell & Kozlowski, 2008). An instructor can practice error framing by explicitly telling the class that it is OK to answer clicker questions incorrectly, by explaining that an incorrect answer is a common misconception, or by suggesting that he or she understands why students might think an incorrect answer was correct. Error framing has been shown to decrease student anxiety about making mistakes (Bell & Kozlowski, 2008), increase student motivation (Steele-Johnson & Kalinoski, 2014), and improve students' connections with faculty (Cooper, Ashley, & Brownell, in press).

In conclusion, most of the student-described anxiety about clicker questions could be classified as achievement anxiety because students' anxiety seemed to stem from a fear of losing points or realizing that they are underperforming compared with other students in the class. However, clicker questions were identified as a way to decrease a broader level of achievement anxiety that related to the students' achievement in science because clicker questions helped them to identify what science topics they do and do not understand, as well as helped them to deepen their knowledge about particular subjects in science.

ACTIVE LEARNING PRACTICE #2: THE RELATIONSHIP BETWEEN GROUP WORK AND STUDENT ANXIETY

Group work is commonly integrated into active learning classrooms because student collaboration to achieve learning goals has been shown to improve student attitudes toward science and increase student achievement (D. W. Johnson & Johnson, 2009; D. W. Johnson, Johnson, & Smith, 2014; Springer, Stanne, & Donovan, 1999; K. Tanner, Chatman, & Allen, 2003). Further, group work allows students to hear and provide diverse opinions as they work toward solving science problems (Katelyn M. Cooper, Ashley, & Brownell, 2017; Lamm et al., 2012). Instructors can integrate group work at any point during an active-learning class. For example, students can work with each other during clicker questions, while engaging with a worksheet, or when the instructor presents an open-ended problem to the whole class. Thus, we chose to explore how working with others affects students' anxiety levels, independent of what activity the group is working on.

Of the students whom were interviewed, 36 students (69.2%) indicated that group work affected their anxiety in some way. Figure 4.2 highlights the specific aspects of group work that influence students' anxiety.

Figure 4.2. Factors That Influence Student Anxiety About Group Work

	Relationship with working partners		Understanding of science concepts		Understanding how science knowledge compares to others	
	Student is comfortable with work partner	Student is uncomfortable with work partner	Student confirms what concepts they do/do not understand	Student clarifies understanding	Student realizes other students struggle with concepts	Student realizes they know less than other students
Effect on student anxiety	↓	↑	↓	↓	↓	↑

Figure 4.2. ↑ indicates a factor that increases student anxiety, ↓ indicates that a factor decreases student anxiety.

Relationship with peers in group work. In this study, we found that much of student anxiety in active learning stems from a fear of being evaluated negatively and in the case of group work, students fear being evaluated negatively by a peer or group of their peers. The fear of being negatively evaluated while participating in a social situation such as group work, or even while simply anticipating participating in group work, is termed fear of negative evaluation (Watson & Friend, 1969; Weeks et al., 2005). Fear fof negative evaluation was described by many of the students in the study, such as Megan, Craig, and Alana, when they talked about how group work influenced their anxiety.

> Megan: If I were talking in a small group and I was not knowledgeable on the topic of the question, then I would feel anxious [because] I would feel more judged by somebody just because I don't want to feel or sound stupid that I don't know what I'm talking about.
>
> Craig: If I realize that I answered a question wrong when talking with people in my group, it makes my anxiety a little worse. I'm sitting there thinking "Oh man, the person next to me probably thinks I'm dumb because I just shared with him the wrong idea."
>
> Alana: I feel less anxious in traditional [lecture] class because there's not that social aspect involved (…) In active learning I worry, 'What are [other students] going to think of me? They probably think I'm dumb for not knowing [the answer to a science question].

While many students' fear of negative evaluation seemed to have a negative impact on their experience in the class, this was not true for all students. For example, Theodore described that working with other students caused him a little anxiety when he doesn't know something but it seemed to motivate him to study more, which has been described as one of the benefits of moderate anxiety levels and why some instructors may perceive that anxiety can be beneficial for students (Jun Zhang, 2001).

> Theodore: It is a little bit anxiety causing when you don't know something, but the person next to you does. There's a little bit of a disconnect in the conversation because one person obviously knows a lot more or maybe did the reading when the other person didn't. That happened to me a couple of times, so it was like, 'This person is way more ahead than I am' (…) It kind of indicates that maybe I should've read more or something.

While a mild amount of anxiety may increase accountability for some students, for others, like Blanca and Parker, the fear of negative evaluation that they experienced during group work can be so severe that it can cause them to think about the experience even after they have left their science class.

> Blanca: I've spent up to a week thinking about [what I've said to my groupmate] (…) I embarrass myself, then I think about it the next time I see them, I'm like, 'What if they bring up last time, that I didn't know the answer? Or what if they make a joke?' Some of the people like to make jokes about, 'Remember last time?' And then I just want to avoid the situation.

Parker: [My anxiety during group work] goes back to the central theme of being judged. Some things I'll say will keep me awake at night. It's like, "Did I overshare? Did I not talk enough?"

Many students, including Cindy, described that their fear of negative evaluation was sufficiently decreased if they had developed a positive relationship with other students in their group because then they perceive that they are less likely to be judged by that person.

Cindy: I feel less uncomfortable bouncing ideas off of [my friend in class] because, I guess when you say something to someone and it's the first thing you've ever said to them, it's like a big impact. It makes a big impression, or it feels that way. Whereas, [my friend] has known me for a year, so I feel like even if I say something stupid she still knows that I'm smart.

Rodger echoes Cindy's experience; he describes that he is more likely to share ideas if he feels comfortable with the person he is working with. He elaborates on the benefits of feeling comfortable sharing more ideas, which he perceives allows him to think more creatively and develop more unconventional ideas.

Rodger: I think a lot of the anxiety in classes comes from the people around you- trying to find someone that you're comfortable with or can talk to. You feel more comfortable being around that person and sharing ideas. And, if we were trying to work through a problem in class, maybe [I'm more likely to] throw out more unconventional ideas. [If you're talking with someone you don't know] it's like, 'Shoot, I should've said [my idea] because it would've been cool if I got [the question] right.' So being able to share those ideas with people around you and

get their feedback (…), I think that's huge for having more creative thinking and thinking outside of the box.

To maximize student comfort, reduce anxiety, and maximize idea sharing, instructors could consider allowing students to choose which other students they work with during class. Previous research suggests that allowing students to choose their own groups during active learning could be particularly anxiety-reducing for students, particularly female and LGBTQIA students (Cooper & Brownell, 2016; Eddy, Brownell, et al., 2015a; Theobald et al., 2017). However, this current study suggests that allowing students to choose whom they work with may reduce all students' anxiety because they can choose partners who they are most comfortable with.

If instructors decide that they want to assign groups, we suggest allowing students to have sufficient time at the beginning of class to introduce themselves and try to quickly establish a level of comfort with each other. Asking students to use name tents, or to write their name on a piece of cardstock that they bring to class, may be another way to allow students to build more personal relationships, especially in large-enrollment courses; students have reported that name tents help them get to know students around them and build community in the classroom (Cooper, Haney, Krieg, & Brownell, 2017a). Additionally, explicitly talking with students about the importance of sharing ideas, even wrong ideas, and stressing how important it is to let all students share their ideas, may alleviate some students' anxiety and encourage more equitable participation (Cooper, Ashley, et al., 2017). Being forthright with students about the importance of equitable participation may also help students without anxiety realize that a student may be quiet in a group, not because they do not have anything to say, but because they are afraid of how

others might react (Cooper, Ashley, et al., 2017). Lastly, allowing students time to think or write before asking them to share their thoughts could also help alleviate anxiety about group work because students have time to synthesize what they would want to contribute to the discussion (K. D. Tanner, 2013b).

Understanding of science concepts and comparing knowledge with others during group work. Students also recognized group work as a way to enhance their knowledge about science, which decreased their anxiety because they perceived that it maximized their ability to do well in the course, on exams, or more broadly in science. Specifically, students, like Quinn, valued that group work allowed them to recognize what science content they do and do not know.

> Quinn: Discussing [science] really helps [decrease my anxiety] because once you get the input of other people, even if you are wrong, it does change your answer and you're like "I can see how they got there or why they got there." (…) Even if my friend and I are both confident about our different ideas, we can be like "let's go through them and see what's wrong." Then you feel extra good because you're like "I can recognize what I don't know and what I do know."

Other students, such as Felicia and Antoinette, highlighted that group work helps them learn more than when they are only listening to the instructor lecture.

> Felicia: I loved discussing [science] with my classmates. Not only do you learn [science] from the professor, you're learning it from your classmates in different terms. So the professor might be not saying it in 'English,' but your classmate

might say it in 'English,' so for sure, definitely the active learning style was so helpful in decreasing my anxiety.

Antoinette: There is anxiety when I am like "Shoot. I don't know what the professor was talking about." I get more anxious. [My anxiety] comes down when I talk to the students around me. Then we talk about the concept, then I'm like, "Okay. I understand this. It's not that hard." (…) I really like group work, to be honest, just because we all just teach each other, that helps a lot.

Felicia and Antoinette's shared opinion that it can be beneficial to hear science described by their classmates in different terms than the instructor uses is supported by previous research that shows that students recognize the benefit of learning science from other students who think more like novices and less like the expert instructor (Cooper *et al.,* under review; Chi, Siler, & Jeong, 2004; Harper & Daane, 1998). Further, studies have shown that peer instruction, or asking students to explain concepts to each other during class, improves student performance on formative assessments such as clicker questions (Crouch & Mazur, 2001; M. K. Smith et al., 2009).

We also found that allowing students to work with each other caused them to evaluate their own understanding as it compares with other students' understanding. A student's perception of their intelligence as it compares with other students' intelligence in a specific domain, such as physiology or biochemistry, has been defined as academic self-concept (Brunner, Keller, Hornung, Reichert, & Martin, 2009b; Herbert W. Marsh & Craven, 1997; Shavelson, Hubner, & Stanton, 1976b). Previous work from our group shows that female students are particularly prone to having low academic self-concept; that is, compared with males, females are more likely to perceive that they are less smart

than their groupmate, even when they have an equivalent or higher GPA than their groupmate (Cooper et al., in press). In this current study of student anxiety, we found that students frequently compared their understanding with others during group work. For some students, such as Monya, comparing themselves with their classmates exacerbated their anxiety if they perceived that they are less smart than the student or students whom they were working with.

> Monya: I usually have friends in my classes with me and they usually know more than I do, so I'm just constantly freaking out and thinking that I don't know as much as they do.

Conversely, we found that if a student interacts with someone in their group and realizes that they both struggle with material, it seemed to reduce their anxiety, as illustrated by *Anne.*

> Anne: When I'm have having trouble with [content] it's like 'It's probably because I'm stupid and don't understand.' But then [talking with other students helps me realize] "OK, everyone else is struggling with the same concept." Or, "Someone else has the same question." So I think it probably helps with more dense concepts and subjects that are just complicated. It kinda helps students relate to other students as well.

Because achievement anxiety has been conceptualized as an ability-linked reaction to failure (Covington, 1992), research suggests that achievement anxiety can be decreased when ability-protecting excuses are available to students (Covington, 1981). For students in this study, recognizing that their groupmates also struggled with science content seemed to serve as an ability-protecting excuse; that is, when students realized that other

students also struggle with science, they were less likely to perceive their own ability as low, which meant that their perception of their own academic ability was "protected," consequently decreasing their anxiety.

In conclusion, students described that working with other students during class could induce achievement anxiety if they feared that students in their group would view them as low achieving or incompetent. Conversely, students reported that group work could decrease their anxiety because it helps them learn and helps them to realize that other students also find science challenging.

ACTIVE LEARNING PRACTICE #3: THE NEGATIVE EFFECTS OF COLD CALL/RANDOM CALL ON STUDENT ANXIETY

Instructors asking student to share their thoughts in front of the whole class without them volunteering to do so is a popular form of formative assessment and has been suggested as an evidence-based active-learning strategy to increase student participation in class (Dallimore, Hertenstein, & Platt, 2013) and student learning (Eddy, Converse, et al., 2015b). There are two common ways that this is done: cold call and random call. Cold call is when instructors either call students by name or point to students to answer a question when the student has not volunteered to answer the question. Random call is a form of cold call, where an instructor randomly calls on students to answer a question in front of the whole class, using a randomly generated list of student names.

Students in this study overwhelmingly reported that when instructors practiced cold call or random call in large-enrollment science courses, it only increased their anxiety and never decreased their anxiety. Thirty-two students (61.5%) mentioned cold

call during their interview. Thirty-one students (59.6%) reported that cold call or random call increased their anxiety and one student (1.9%) said it did not affect their anxiety. In contrast to the other active learning practices explored in this study, not a single student mentioned that cold call or random call could decrease their anxiety.

Fear of negative evaluation underlies student anxiety during cold call. Students' anxiety about instructors practicing cold call or random call seemed to be driven by the fear of negative evaluation or the sense of dread associated with the potential to be negatively evaluated by others (Watson & Friend, 1969), as illustrated by Celeste and Lidia.

> Celeste: That's what I'm afraid of when getting called on in front of the whole class, getting it completely wrong, or not saying anything. (...) If you don't know, you're that one person who seems stupid. That's what I feel like. Not knowing the answer makes me feel anxious, makes me feel like I'm the outcast, the stupid one.

> Lidia: Having to speak in front of a large group of people makes me anxious. It's the fear of being wrong or sounding dumb- being embarrassed.

Some students acknowledged that their fear of being evaluated was exacerbated when cold call was practiced in large classes.

> Parker: Smaller class sizes [compared to large classes] would decrease my anxiousness. It's like a comfort thing, less people looking at me. Logically, I know that people don't actually do this, but it's fewer people who are going to be like "That kid in class said something stupid today." It's fewer people who are going to be potentially talking about me. I know logically that's not something that I should be worried about, but [it still increases] anxiety.

While students seemed to recognize that instructors likely practice cold call or random call to enhance their learning, they felt as though the anxiety associated with the anticipation of speaking out in front of others negatively impacted their learning and performance**.** More specifically, students, such as Celeste, Quinn, and Emmy, described that they were unable to think through a science problem posed to the class because they were afraid of being called on by the instructor.

> Celeste: My brain stops. [If the instructor] asks me a question, I have no idea what the answer is. If you were asking me in a small group, yes I'll tell you the answer and get it. If in a large group, my brain just stops. I have no idea why.
>
> Quinn: I think it's the pressure of not only having to answer a question in front of a professor who clearly knows the answer, but in front of all your peers as well [that causes me anxiety]. It kind of clouds your thinking and then you feel like you can't think at all and it just gets worse. Your heart is racing, you start to sweat, and your brain just shuts off. You're looking for an answer, but then you can feel that there's pressure there so you're not actually thinking of a good answer.
>
> Emmy: It also happened once in chemistry, [the instructor] just pulled me up and he's like, 'Hey. You're going to answer this question.' For me if it's unexpected, I really don't like it. I just forget everything. I don't know what I'm doing. Then I'm really nervous because I feel like everyone is watching you. I don't know what to do. (…) I freeze up and I can't really say they answer but I kind of have to have something come out in order for the teacher to be happy.

These students' experiences are consistent with literature that suggests that individuals with fear of negative evaluation focus a significant amount of their attention on monitoring their environment for a possible threat of evaluation, such as the threat of being called on in front of the whole class, and therefore, have less cognitive capacity to engage in other activities, such as thinking through a science problem (Heimberg, Brozovich, & Rapee, 2010). Additionally, anxiety has been hypothesized to be debilitating for a student's performance when a task (e.g. speaking in front of the class) is introduced in a way so that poor performance can reflect negatively on the student (Sarason, 1973; Stipek, 1993).

Students, such as Serena, Jordan, and Emmy, also reported that when they were called on and had to speak out in front of others, their anxiety caused them to lose their train of thought or they were unable to clearly articulate their ideas, which in turn further heighted their anxiety.

> Serena: Being random called, that level of anxiety, it just throws me. [When anticipating being called on by the instructor] I knew the answer in my head, but just being in that moment [being called on], I just wasn't able to put those thoughts into a clear, coherent sentence. It just made me feel bad. I felt sick to my stomach. It doesn't really help you because then you're just inhibited.

Jordan: I have the thought in my head, but it doesn't come out necessarily the way I want it to. It's hard to explain myself.

Emmy: I'll spit something out and the teacher is like, "I don't understand. Can you restate that?" I'll have to sit there and figure out how to reword what I just said without sounding like an idiot.

High levels of anxiety have been predicted to be especially detrimental to learning when students are required to hold and manipulate speech-based information (Eysenck & Calvo, 1992; Owens, Stevenson, Norgate, & Hadwin, 2008; Rapee & Barlow, 1991) and can prevent students from clearly articulating their thoughts in front of others. Further, if students experience fear of negative evaluation, they are likely evaluating their own behavior (e.g. monitoring if they are sweating, misspeaking, stuttering, etc.), which increases cognitive load and can compromise their ability to successfully articulate their thoughts about science in front of hundreds of other students (Heimberg et al., 2010).

While a previous study suggests that practicing cold call or random call should cause students to become more comfortable speaking out in class (Dallimore et al., 2013), we found that cold call and random call had the opposite effect on the students who we interviewed. Many students described that if they experienced being called on, especially if they struggled to think through the science question or articulate their thoughts, they were less likely to want to participate in the future.

Emmy: [After being called on in front of the class] I sit there and I'm like 'I can't believe I didn't know the answer to that.' I beat myself up over it. I'm still really nervous about it afterwards because it's like, 'I can't believe that happened.' (…)

Then, I become a lot more quiet. I don't put myself out there anymore. It kind of hits a switch and I'm not going to participate as much in class after that point. I feel like I don't want to do that again. (…) Usually when those anxiety attacks are that extreme, I try to stay away from anything that's going to promote the same thing.

Quinn: [When instructors cold call students] it really just puts me more on edge because I know that feeling and I know [getting called on randomly] could happen again. It's not like one of those things you're like "Oh it's over, it wasn't that bad." No, it was that bad, and I did not like it. A lot of people stop coming to lecture for that very reason, which I'm sure is the opposite of what [the instructor] wanted.

Students wanting to avoid cold call or random call after they have had a negative experience, or even after they perceived that a classmate has had a negative experience, is consistent with psychology literature which suggests that if students have a negative experience in class, then their fear of negative evaluation, and consequently their anxiety, is only going to be exacerbated in future situations (Heimberg et al., 2010). Thus, we would predict that repeatedly exposing students to cold call or random call would not help to decrease their anxiety unless they had a positive experience, which none of the students in our study described (Heimberg et al., 2010).

Random call has been recommended as an alternative to hearing out from volunteers in class as a way to create a more equitable classroom environment (Eddy, Brownell, & Wenderoth, 2014c; K. D. Tanner, 2013b) because certain students can dominate whole class discussions, either because they are more willing to volunteer to

share an answer or because instructors are more likely to call on particular students (Eddy et al., 2014c). However, evidence suggests that, compared to their male peers, females experience disproportionately more anxiety than males in whole class discussions (Eddy, Brownell, et al., 2015a), which suggests that while cold call and random call may be more equitable with regard to which student voices are heard, they may not afford students an equitable experience during class because females may still experience more anxiety than males in those whole class discussions. Further, despite the calls to hear out from students in front of the whole class, we can find little evidence that directly links cold call or random call in science courses to student benefits such as student-learning gains. In a recent study by Broeckelman-Post and colleagues (Broeckelman-Post, Johnson, & Schwebach, 2016), students in a large-enrollment college biology course reported that the practice of cold calling students during class encouraged them to pay attention, attend class, discuss ideas, and listen to other students. Yet, these same students also reported experiencing anxiety as a result of cold call, and students with anxiety disorders reported that the practice of cold calling resulted in frequent absences from class, and heightened their anxiety and a "sense of feeling under pressure when in class" (Broeckelman-Post et al., 2016). We only found the negative effects of cold call in this study: the students whom were interviewed in our current study suggested that they ultimately struggled to pay attention in class because once the threat of cold call or random call was introduced, they were preoccupied with worrying about how others might perceive their intellectual capability if they were to be called on. Given the degree to which cold call can increase student anxiety and lack of evidence for the benefits of

cold call, it seems as though we as a community could find alternative ways to engage students in class that would not elicit high anxiety for students.

Considering the literature on the negative effects of high anxiety on student learning and performance and the results of this study, in addition to the paucity of evidence on the benefit of cold call or random call on student learning in science, we suggest that instructors consider other means of sharing student ideas with the whole class. While we do not recommend only hearing out from students who volunteer because this has been shown to lead to gender inequities in whose voices are heard (Eddy et al., 2014c), we suggest an alternative where instructors can walk around during group work and gather ideas from students and then share those ideas out with the entire class. This allows instructors to transform students' ideas into complete, accurate thoughts before reporting them out, which can reduce anxiety for the student who would have shared and can also lead to less confusion for other students in the class who may not have understood the response shared out by the student. Furthermore, if instructors are thoughtful about sharing out ideas from students whose identities are underrepresented in science, this practice may even be a way to promote equity in the classroom. We acknowledge that many variables contribute to how instructors facilitate whole class discussions, including the size and layout of the classroom, so we do not assume that there is one solution that works for every classroom.

In conclusion, we found that cold call and random call only exacerbated students' anxiety and no students identified ways in which these practices could decrease their achievement anxiety. Overwhelmingly, students' anxiety seemed to be rooted in a fear of negative evaluation.

LIMITATIONS

We acknowledge that this study was done in the context of one institution. Although students were asked about their experiences in science classrooms, students were only recruited from introductory biology and upper-level physiology courses. Before broad generalizations can be made, a more systematic analysis of these practices with larger numbers of students should be done. Further, we only report here on three active learning practices. There may be other active learning practices that generate greater levels of anxiety that we did not explore. Finally, because this study was exploratory and we did not ask every student about whether a specific practice increased or decreased their anxiety, we did not systematically analyze whether there were differences in how active learning practices affected students with minimal, mild, moderate, and severe anxiety. However, this would be an important area of future research.

CONCLUSIONS

The three active learning practices that were explored in this study, clicker questions, group work, and cold call/random call, all had the potential to increase students' anxiety. Fear of negative evaluation was identified as a construct underlying students' achievement anxiety during active learning activities. Both clicker questions and group work also had the potential to decrease student anxiety because students felt that these active learning practices helped them to learn science. We identified specific aspects of clicker questions, group work, and cold call/random call that can negatively impact students' anxiety levels and we hope these findings will help instructors to create more inclusive active learning science classrooms.

CHAPTER 5

WHAT'S IN A NAME? THE IMPORTANCE OF STUDENTS PERCEIVING AN INSTRUCTOR KNOWS THEIR NAMES IN A HIGH ENROLLMENT BIOLOGY CLASSROOM

ABSTRACT

Learning student names has been promoted as an inclusive classroom practice, but it is unknown whether students value having their name known by an instructor. We explored this question in the context of a high-enrollment active learning undergraduate biology course. Using surveys and semi-structured interviews, we investigated whether students perceived that instructors know their name, the importance of instructors knowing their name, and how instructors learned their name. We found that while only 20% of students perceived their names were known in previous high-enrollment biology classes, 78% of students perceived that an instructor of this course knew their name. However, instructors only knew 53% of names, indicating that instructors do not have to know student names in order for students to perceive that their names are known. Using grounded theory, we identified nine reasons why students feel that having their names known is important. When we asked students how they perceived instructors learned their names, the most common response was instructor use of name tents during in-class discussion. These findings suggest that students can benefit from perceiving that instructors know their names and name tents could be a relatively easy way for students to think that instructors know their name.

Learning student names is generally promoted as a good teaching practice (Chambliss, 2014; Kelley & Gorham, 1988; Page, n.d.; K. D. Tanner, 2011, 2013b; Zakrajsek, 2007), yet the research literature on this practice is relatively sparse. Most of these recommendations are in the form of teaching tips that often summarize anecdotes or report from a general faculty perspective that learning names is important because it can build student-instructor relationships (K. D. Tanner, 2011), help create a positive classroom atmosphere (K. D. Tanner, 2013a), and serve as an indicator that an instructor cares (K. D. Tanner, 2011). However, we know of no research literature that actually links student perception of their names being known to affective student outcomes.

The limited published data on the benefits of knowing student names is typically situated within the literature on instructor immediacy. Instructor immediacy is the perception of physical and psychological closeness between students and an instructor (Mehrabian, 1971). Immediacy behaviors can be nonverbal (e.g. smiling, gestures while talking, appropriate touch) (Richmond, Gorham, & Mccroskey, 1987) or verbal (e.g. uses terms like "we" to describe the class, gives students feedback, allows students to call the instructor by his or her first name) (O'Sullivan, Hunt, & Lippert, 2004). Instructor immediacy has generally been positively correlated with perceived instructor responsiveness (Thomas, Richmond, & McCroskey, 1994), perceived instructor caring (Thweatt, 1999), and positive student evaluations (Moore, Masterson, Christophel, & Shea, 1996). Moreover, instructor immediacy appears to impact students themselves: instructor immediacy has been positively correlated with student participation (Christensen & And Others, 1995; Menzel & Carrell, 1999; Rocca, 2004), student affect

(Kelley & Gorham, 1988), and even student learning (Chesebro & McCroskey, 2001; Christophel, 1990; Kelley & Gorham, 1988; Titsworth, 2001).

While instructor immediacy has been shown to improve student experiences in traditional lecture, we know very little about how instructor immediacy influences students in active learning classrooms. In contrast to traditional lecture, students in active learning classrooms are expected to interact more frequently with each other as well as with the instructor (Katelyn M. Cooper & Brownell, 2016a; Eddy, Brownell, et al., 2015b; Eddy et al., 2014a; Seidel, Reggi, Schinske, Burrus, & Tanner, 2015). Therefore, we hypothesize that active learning classes can provide a greater number of opportunities to build immediacy between instructors and students. However, there are few studies that have explored instructor immediacy in the context of active learning classrooms. In one study, Seidel and colleagues (2016) explored Instructor Talk, a verbal immediate behavior, in an active learning classroom. Instructor talk refers to any language used by an instructor that is not directly related to the course concepts, but instead focuses on creating the learning environment (Seidel *et al*,. 2015). The authors of this study hypothesized that types of instructor talk, such as demonstrating respect for student and sharing personal experiences, may increase instructor immediacy in active learning classrooms.

While the literature suggests that immediate instructor behaviors can lead to positive student outcomes broadly, we are unaware of any studies that have specifically examined the impact of an instructor knowing a student's name. Despite this lack of evidence, learning student names is frequently recommended as a simple instructional practice to build immediacy with students (Chambliss, 2014; Kelley & Gorham, 1988;

Page, n.d.; Zakrajsek, 2007). Instructors of small enrollment courses are often able to follow this recommendation and can learn some to all of the student names in their courses. However, it is unclear whether instructors of large enrollment courses commonly learn student names. While there are rare examples of highly immediate college instructors who report learning hundreds of student names in large classes (K. D. Tanner, 2011), we assume that many instructors of large enrollment courses resign themselves to the reality that they will not learn most student names in their course. If instructors learn only a few names, it is also unknown which student names are learned by instructors. Although studies suggest that males are more likely to speak out and be remembered by their peers in large enrollment biology courses ((Eddy et al., 2014c; Grunspan et al., 2016b), we do not know if this affects which student names are known by instructors. More specifically, it is unknown whether student identities such as gender, race/ethnicity or college generation status influence which names instructors learn. Finally, since there are no studies that have examined the impact of using student names in the context of a large enrollment undergraduate classroom, we do not know whether students in large enrollment courses would even perceive benefits from an instructor knowing their name.

While the large numbers of students in high enrollment courses make *learning* student names difficult, there are a number of strategies that instructors can use to be able to *use* student names even if they do not actually know the student's name. One such strategy is having students display their names in class via name tents, a folded piece of card stock with a student's name written on it, so that instructors can use their names when interacting with the student (K. D. Tanner, 2011, 2013b). Not only can name tents

help instructors learn student names, they can help instructors call students by name even when the instructor does not know the student name. This presents the question of whether students benefit from an instructor using their names or whether an instructor actually needs to know that student's name.

In this study, we explored student perceptions of instructors knowing their names in a large enrollment undergraduate biology course that was taught in an active learning way. This study is novel in that we know of no other study that has linked student perception of instructors using names to student affective gains. Further, we know of no other study that has explored the use of names in a large enrollment course. Our specific research questions were:

1. To what extent do students perceive that instructors of large enrollment undergraduate biology courses know their names and does it align with whether an instructor actually knows their name?
    a. To what extent do demographic characteristics predict which students perceive that instructors know their names?
    b. To what extent do demographic characteristics predict which student names are actually known by an instructor?
2. Why, if at all, do students think that it is important to have their names known in a large enrollment biology course?
3. How do students perceive that an instructor learned their name?

COURSE DESCRIPTION

All data were collected from a large enrollment, upper level biology course comprised of 185 students. The class was taught in an active learning format; every class

session included student-centered instruction, typically using a combination of clicker questions accompanied by peer discussion and group work using worksheets. The class met three times a week for 50 minutes each; two days each week were held with all 185 students in a traditional stadium seating lecture hall with two aisles. One day each week, students attended a recitation section with ~60-70 students, which was held in a scale-up classroom with round tables.

The course was co-taught by two instructors with significant teaching experience. Both instructors were committed to using student-centered approaches to teaching. Students earned course points for participating during lecture and recitation, which encouraged students to attend every class. Students were incentivized to attend office hours by earning one extra credit point for every time that they attended office hours. Multiple office hours were offered throughout the week and extra opportunities were available the week before exams. A select group of ten honors students met every other week outside of the scheduled class time to read primary scientific papers and one instructor attended each session.

On the first day of class, all students were provided with piece of brightly colored cardstock and a marker and asked to make a name tent (see Figure 5.1 for an example). Students were asked to bring their name tent to class every day and display it on their desks. Throughout the course, students were greeted by teaching assistants as they came into class and were reminded to take out their name tents. Additionally, the first lecture slide of most lectures reminded students to display their name tents. The instructors brought the materials to make new name tents to every class; if students forgot to bring

their name tents, they were invited to make a new one at the beginning of the class period.

Figure 5.1. Example Name Tents

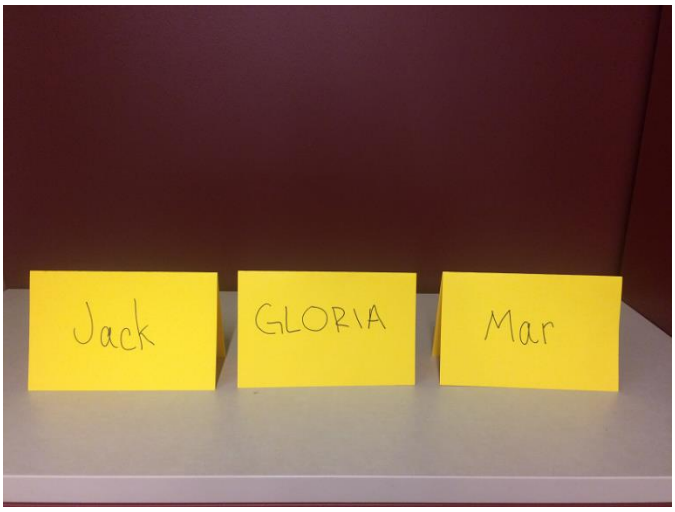


Figure 5.1 Students use markers to write their first name on a folded 8 x 10 inch piece of card stock.

METHOD

DATA COLLECTION

Pre-course survey. During the first week of class, students completed a survey that asked about their prior experiences in large enrollment biology courses. Large enrollment courses were defined as courses of 50 students or more. Students were asked how likely it was that instructors of previous large enrollment biology courses knew their name and responded on a four point Likert-scale ranging from very likely to very unlikely. These data were later collapsed into two categories, likely and unlikely. Student demographic information was also collected, including race/ethnicity, gender, and college generation status.

Post-course survey. On the last day of class, we provided all students with a list of the two instructors of the course. We asked students to circle which of the instructors, if any, knew their name. If a student thought an instructor knew their name, we asked them to describe how they thought the instructor learned their name. Lastly, we asked students to please explain why instructors knowing their name was or was not important to them.

Interviews. Students in the course were offered several options to earn extra credit at the end of the semester. One of the ways in which students were able to earn the credit was to participate in an interview to give their feedback on the course. To provide anonymity and to encourage students to speak freely about their experience in the course, students were assured that instructors of the course would never listen to the interviews or associate their names with their responses. We designed interview questions to explore student conceptions of affective instructional practices, including instructors knowing student names. We created interview questions based on the findings of Seidel and colleagues (2015) and preliminary data collected from three sources during the previous term: student nominations for one of the instructors for a teaching award, general feedback from the students about what they had liked and disliked about the course, and formal student evaluations. We asked students whether they felt the instructors fostered relationships with students, built a classroom community, and cared about student success. If students indicated that one or both of the instructors established relationships with students, built a classroom community or cared about students, we asked the student how they thought the instructor did so. At the end of the interview, we also asked students if they thought that either of the instructors knew their name. If a student

reported that they perceived an instructor knew their name, we asked them how they thought the instructor learned their name. We asked all students whether or not having their name known was important to them and what their opinions were of using name tents in class. In the interviews, we asked students the same set of questions for each instructor and we combined those responses because we are interested in how students perceive and interact with the instructors generally.

Student name identification. Within three days of the last day of class, each instructor was asked to identify the first names of students in the class. Each instructor was individually presented with a photo roster of the class with the names of students removed. They looked at individual pictures of all students and were asked to name as many students as they could. This information was recorded into an Excel sheet.

This study was done in accordance with an approved IRB.

DATA ANALYSIS

Responses to post-course survey. We began by analyzing student responses to the post-course survey. We used grounded theory to identify themes from the student responses to the question "Please explain why instructors knowing your name is or is not important to you?" (Glaser & Strauss, 2009). Constant comparison methods were used throughout the analysis (Glesne and Peshkin, 1992). Quotes that were assigned to themes were gathered together and compared to one another throughout the analysis. This iterative comparison of quotes was meant to ensure that the description of the theme adequately represented all quotes within the same group and that the quotes were not different enough from one another to warrant a separate category. As a result of this process, we created a coding rubric.

Three of the authors (KMC, BH, and SEB) coded all student survey responses together and came to consensus when they disagreed. In order to establish that the coding scheme was reliable and could be used to replicate the results by other researchers, another author (AK) independently coded 25% of the statements coded by the other authors in the final round of coding and the two results were compared. The authors had a consensus estimate of 99% (Stemler, 2004).

Analysis of interviews and data triangulation. All interviews were transcribed and anonymized to protect student identities. We used a combination of grounded theory and content analysis to identify interesting themes that emerged from the interviews. Additionally, we used content analysis to analyze responses to the interview question about whether an instructor knowing a student name was or was not important, using the previously established rubric. The purpose of analyzing student answers to this question was to see if student responses could be coded into the themes that were already established by analysis of the post-survey question, or whether new themes would emerge. All student responses fell into at least one of the nine previously established themes and no new themes emerged. In order to triangulate and further validate our findings, we analyzed student interview responses to questions about affective elements of the course to determine if students mentioned instructors knowing their names. One author (BH) reviewed each question in every interview and identified whether student mentioned the classroom practice of knowing student names as part of their response.

Statistical analyses. Previous literature suggests that students may be more or less likely to have their names known based on their academic ability level, gender, race/ethnicity and college generation status (Terenzini *et al.*, 1996; Eddy *et al.*, 2015;

Grunspan *et al.*, 2016). Therefore, we used this hypothesis to inform a generalized linear model. Using generalized linear modeling we explored whether student prior academic ability, gender, race/ethnicity and college generation status predicted whether students reported that they were likely to have their name known in previous large enrollment biology courses, whether students perceived their names were known by an instructor, and whether a student's name was actually known by an instructor. The models are described in Table 5.1.

RESULTS

CLASS DEMOGRAPHICS

In this course, 59% of students identified as female, 40% as male and 1% as other. Sixty-two percent of students identified as white, 13% as Hispanic, Latin@ or Spanish origin, 7% as Asian, 6% as black or African American, 1% as American Indian or Alaska native, 9% as other, and 2% declined to state. Twenty-four percent of students identified as a first generation college student, 74% identified as a continuing generation college students and 2% declined to state.

FINDING 1: WHILE MOST STUDENTS REPORT THAT IT WAS UNLIKELY TO HAVE THEIR NAME KNOWN IN PREVIOUS LARGE ENROLLMENT BIOLOGY COURSES, 75% REPORT THAT AN INSTRUCTOR OF THIS COURSE KNEW THEIR NAME

Likelihood of student name known in a previous large enrollment biology course. Of the 185 students enrolled in the course, 171 (92.4%) responded to the pre survey during the first week of class and 157 of these students (91.9%) reported previously having been enrolled in a large enrollment biology course. Of these 157

students, 125 (79.6%) reported that, considering all of the large enrollment biology courses they had previously been enrolled in, it was *unlikely* that an instructor knew their names during the course. Only 32 (20.4%) students reported that it was likely that an instructor knew their names during previous courses (Figure 5.2a).

We explored whether student prior academic ability (measured by cumulative GPA at the beginning of the semester) or student social identities including gender, race/ethnicity, and college generation status predicted whether students were likely to report having their name known in previous large enrollment biology courses. We found that female students were significantly (0.35x) less likely than male students to report that it was likely that an instructor in previous large enrollment biology courses knew their name (Table 5.1a), but we did not observe differences based on prior academic ability, race/ethnicity or college generation status.

Figure 5.2. Student Perceptions That Their Names Were Known in Previous Courses and in Their Current Course

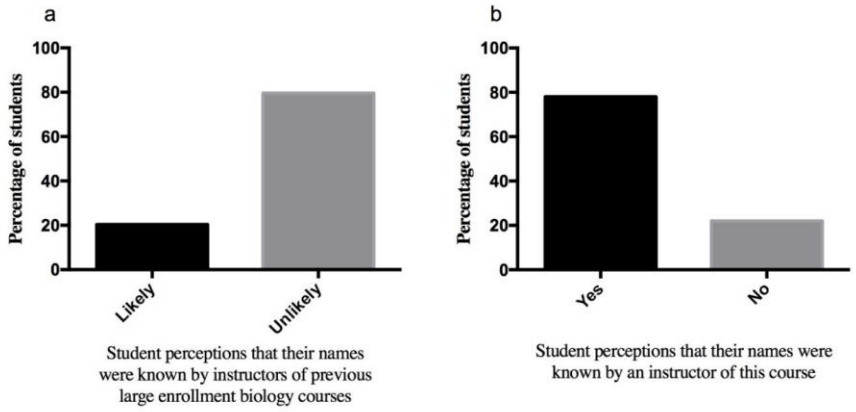


Figure 5.2. a. Considering all previous large-enrollment biology courses that students had been enrolled in, 125 students (79.6%) reported that it was unlikely that instructors knew their names during the course and only 32 students (20.4%) reported that it was likely that instructors knew their name during the course. b. In considering this course, 136 students (78.1%) perceived that an instructor of this course knew their name and 38 students (21.8%) reported that an instructor of the course did not know their name.

Table 5.1

Results of Models Which Explore Whether Student Demographic Characteristics Predict a. If a Student Perceives That it is Likely That Instructors of Previous Large Enrollment Biology Courses Knew Their Name b. If a Student Perceives That Instructors of this Large Enrollment Biology Course Know Their Name and c. If an Instructor of This Large Enrollment Biology Course Actually Knew the Student's Name

	a. Likely to report name previously known		b. Student perceives name is known by instructor		c. Student name actually known by instructor	
	Regression coefficient[1] ± SE	p value[2]	Regression coefficient[1] ± SE	p value[2]	Regression coefficient[1] ± SE	p value[2]
Intercept	-4.0 ± 1.4	**0.00517**	0.13 ± 1.18	0.912	0.10 ± 0.45	0.674
Prior GPA	0.77 ± 0.40	0.05302	0.46 ± 0.35	0.197	0.01 ± 0.01	0.267
Gender *female*	-1.05 ± 0.46	**0.02270**	-0.12 ± 0.43	0.794	-0.35 ± 0.36	0.321
Race *urm*	0.24 ± 0.56	0.66732	-0.65 ± 0.46	0.159	-0.39 ± 0.41	0.334
College generation status *first-generation*	0.80 ± 0.67	0.23605	-0.03 ± 0.48	0.947	-0.19 ± 0.40	0.637

Note. [a]The first model explores whether a student's prior academic ability, gender, race/ethnicity, or college generation status predicts if they perceived it was likely or unlikely that instructors previous of large-enrollment biology courses knew their names. Model[a]: name.previously.known ~ prior.gpa + gender + race + college.gen. [b]The second model explores whether a student's prior academic ability, gender, race/ethnicity or college generation status predicts whether they perceive that an instructor in this class knew their name. Model[b]: instructor.perception ~ prior.gpa + gender + race + college.gen. [c]The third model explores whether a student's prior academic ability, gender, race/ethnicity, or college generation status predicted whether an instructor actually knew their name. Model[c]: name.actually.known ~ prior.gpa + gender + race + college.gen. [1]Regression coefficients +/- standard error. [2]Bolded *p* values are significant.

Perception of whether student name was known in this course. Of the 185 students originally enrolled in the course, 174 students (94%) responded to the post-course survey. Of these 174 students, 136 (78.1%) perceived that an instructor of this large enrollment upper-level biology course knew their name and 38 (21.8%) perceived

that their name was not known (Figure 5.2b). We examined whether student prior academic ability, gender, race/ethnicity, and college generation status predicted whether students perceived that an instructor knew their name. We found that none of these variables predicted whether a student perceived that their name was known by an instructor of this course (Table 5.1b). Therefore, despite female students being less likely to perceive that their names are typically known in large enrollment biology courses, they were just as likely as male students to perceive that their names were known in this course.

Which names instructors actually knew. Even though 136 students (78.2% of the class) perceived that their names were known, instructors were only able to name 92 students (53.0% of the class) when they looked at de-identified roster photos of the students (Figure 5.3). Five students (2.9% of the class) perceived that an instructor did not know their names despite the fact that an instructor actually knew their names and 33 students (19.0%) correctly assumed that their names were not known by an instructor (Figure 5.3). Therefore, of the 136 students who perceived that their names were known, instructors actually knew 87 of these student names (64.0% of students who perceived their names were known), which means that 49 students (28.2% of the class) perceived that an instructor knew their name when they actually did not (Figure 5.3). This implies that instructors do not always have to know student names in order for students to believe their names are known. We examined whether student prior academic ability, gender, race/ethnicity, and college generation status predicted whether an instructor actually knew student names. We found that none of these variables predicted whether a student's name was actually known by an instructor (Table 5.1c).

Figure 5.3. Whether Students Perceived an Instructor of the Course Knew Their Name and Whether an Instructor Actually Knew Their Names

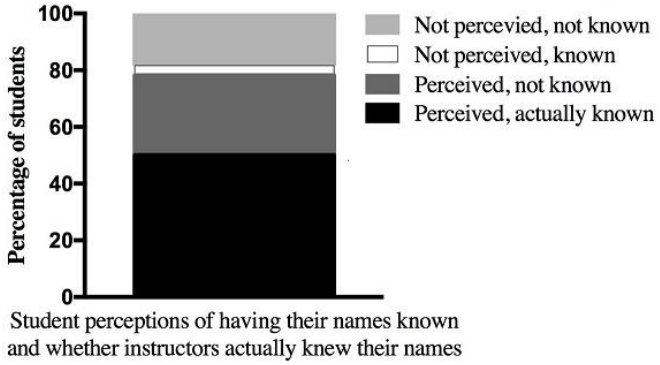


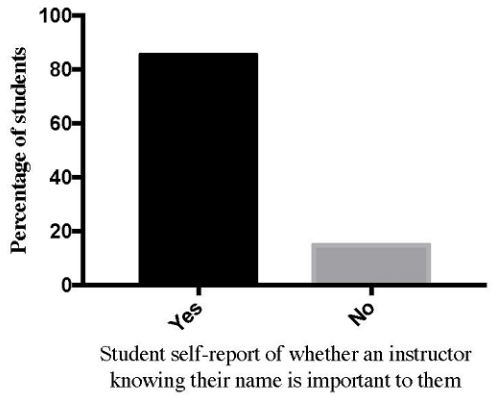
*Figure 5.3..*Of the 174 students who completed the post-course survey, 87 students (50.0%) correctly perceived that an instructor of the course knew their name. An additional 49 students (28.1%) perceived that an instructor of the course knew their name but their names were not actually known by instructors. Five students (2.9%) incorrectly perceived that their names were not known by an instructor, when the actually were and 33 students (19.0%) correctly perceived that their names were not known by an instructor of the course.

FINDING 2- STUDENTS REPORT THAT INSTRUCTORS KNOWING THEIR NAMES IS IMPORTANT TO THEM

Students perceive that it is important for instructors to know their names.

Of the 174 students who completed the post-course survey, 157 students (90.2%) responded to a question that asked whether they thought it was important that instructors knew their names. One hundred and thirty four (85.4%) students said it was important for instructors to know their name, while 23 (14.7%) said it was not important (Figure 5.4).

Figure 5.4. Student Responses to the Question "Is it Important That Professors Know Your Name?"



Why students perceive an instructor knowing their name is important. We asked students who reported that it was important that an instructor knows their name to explain why it was important to them. We used grounded theory to code student responses, which generated nine reasons that were mentioned by at least 5% of students in the course (Glaser, Strauss, & Strutzel, 1968). We chose 5% as a cut-off for reporting results because that meant that at least six students perceived that theme as a benefit. Since this is an exploratory study, we wanted to be as inclusive as possible in our initial category formation. Because students were able to write as much as they wanted in response to the open-ended question, some students mentioned multiple reasons. Seventy-two students (54%) reported out more than one reason as to why having their name known by an instructor is important to them and the average number of reasons per student was 1.66. However, students were not instructed to make an exhaustive list, so it is likely that we are underestimating the number of students who perceive that a particular reason is important.

Students reported that having their name known by an instructor affects their attitudes about the course (Table 5.2). The most common student response for the importance of knowing student names was that the student feels valued in the course (41 student responses, 30.6%). Additionally, 26 students (19.4%) mentioned that when an instructor knows their name they feel more invested in the course. Students also indicated that having their name known affects their behavior in the course (Table 5.2). Twenty-six students (19.4%) said that they would feel more comfortable seeking help from the instructor, and 16 students (11.9%) mentioned that they would feel more comfortable talking to the instructor about topics unrelated to the content such as scheduling conflicts or personal struggles. Sixteen students (11.9%) said that they felt as though they perform better in a course when their name is known by an instructor.

Students also described how having their name known affects how they perceive both the course and the instructor (Table 5.2). Thirty-six students (26.9%) wrote that when an instructor knows their name it makes them feel as though the instructor cares. Interestingly, 31 students (23.1%) mentioned that it helps to build student-instructor relationships, however only 9 students (6.7%) reported that having their name known would increase the chances that an instructor of the course would mentor them or provide them with a letter of recommendation. Students also perceived that when instructors know student names it helps to build classroom community (19 student responses, 14.2%).

Table 5.2

Student Perceives That Having Their Name Known by an Instructor is Important to Them for Nine Distinct Reasons that fall into Three Larger Categories

Why important that instructors learn your name	% Student responses (n = 134)	Example student quote	Example student quote
Affects student attitudes about the course			
Student feels more valued	30.6%	“A professor knowing your name makes you feel as if you're a part of the process, rather than just being swallowed by it.” -Elaine	"I feel like I'm just a face in the crowd most of the time, even in classes where the teacher is really excited about teaching and helping students understand. Knowing my name makes me feel more noticed and welcome." -Jamie
Student feels more invested in the course	19.4%	"Instructors knowing your name can be rather inspiring for a student to want to achieve more in class." –Graham	"When I feel that personal connection with the instructors it makes me want to do better in the class as well, it’s almost as if I'm extra accountable." –Lloyd
Affects student self-reported behavior			
Student feels more comfortable getting help	19.4%	"[An instructor knowing my name] makes me feel more comfortable asking questions/getting help on subjects." -Whitney	"[An instructor knowing my name] makes it easier to motivate myself to come to office hours/get help with concepts if I know the professor on a level higher than just ‘my professor.’” -Jorge
Student feels more comfortable talking to the instructor	11.9%	"Often students think that instructors don't care about personal things going on in life that can affect a student's work and [when instructors know your name] it can be easier to share if you had a good day/bad day/etc." –Jewel	"[Instructors knowing my name] definitely made me more confident about approaching the professor when I had a scheduling conflict" -Tracey
Student feels enhanced performance in the course or confidence in the material	11.9%	“I think having an instructor know the student names can only boost student performance.” –Rick	"[Instructors knowing my name] creates a more comfortable dialogue and therefore increases confidence in lecture material." -Grayson
Affects how the student perceives the course or the instructor			

Student feels an instructor cares	26.9%	"The instructors knowing my name was important because it made me feel like they cared. If they cared enough to remember my name in such a large class, it showed me that they cared about my experience in the class and education." -Kaylie	"[Instructors knowing student names] shows that the instructors care about all of the students individually and they have invested interest in ensuring that everyone feels welcome and that they have every opportunity to succeed in the course" -Bettie
Student feels it builds student-instructor relationships	23.1%	"When instructors know your name, they kind of get to know you on a more personal level and this could make learning a better experience." -Carolyn	"[Instructors knowing student names] indicates that more personalized one-on-one interaction has occurred which will likely lead to greater mutual respect" -Steven
Student feels it builds classroom community	14.2%	"[Instructors knowing student names] is important to me because it provides a more welcome atmosphere where students feel comfortable sharing their ideas even if they are wrong or way off." -Delores	"[Instructors knowing student names] is important to create a sense of community in the classroom, which is especially important for active learning." -Tyson
Student feels that instructors are more likely to provide student with letter of recommendation or mentoring	6.7%	"[Instructors knowing my name] is essential because in the case I may need a reference or for someone to recommend me for either a lab or any sort of job opportunity. Also they are great sources of career advice and guidance in my educational and biological career." -Charles	"Getting to be known by my professor has generally been something that's important to me. I like building connections and enjoy opportunities for greater mentorship." -Denise

To triangulate student responses on the post-course survey, we analyzed a set of student interviews aimed to explore student perceptions of the affective components of this course. Specifically, we asked if students felt as though the instructors of the course cared about their success, built relationships with students, and built classroom community. Students were also asked whether instructors structured the class so that all students could succeed, and whether they felt that the instructors cared about their success after the course ended. We analyzed these interviews to see whether students mentioned instructors knowing student names during their responses to these questions. Notably, 25 students (73.6%) said that instructors built relationships with students in the

class by knowing their names and 16 students (47.1%) said that instructors knowing student names contributed to why they thought the instructors cared about their success in the course (Table 5.3). Furthermore, seven students (20.6%) said that instructors knowing student names contributed to the instructors' abilities to build classroom community (Table 5.3).

Table 5.3

The Percent of Students That Brought Up Instructors Knowing Their Name in Response to Interview Questions About Affective Components of the Course

Interview question	Percentage of interviewees who mentioned an instructor using their name (n=34)
Do you feel that the instructors care about your success and why?	47.1%
Do you think that the instructors of this course built relationships with students? If so, how?	73.6%
Do you think that the instructors of this course built a classroom community? If so, how?	20.6%
Do you think that the instructors of this acourse structured the class so all individuals could succeed? If so, how?	2.9%
Do you feel that instructors care about your success after this course and why?	2.9%

FINDING 3- STUDENTS REPORT A VARIETY OF WAYS THAT THEY PERCEIVE INSTRUCTORS LEARN THEIR NAMES

Due to the large number of students in this class who perceived that their names were known by instructors and how important it seemed to students for instructors to know their names, we wanted to explore student perceptions of how instructors learned their names in a large enrollment class.

Students perceived that instructors learned their names in a variety of different ways. Of the 136 students who perceived that an instructor of the course knew their

name, 133 (97.8%) explained how they thought an instructor learned their name. A student could provide multiple reasons for how one or both instructors learned their name. Students reported that they thought the instructors learned their names through methods both inside and outside of the classroom (Table 5.4). For example, 58 students (43.6%) cited that they thought their name was learned through the use of name tents. Notably, this class was taught in an active learning way, which provided ample opportunities for instructors to walk up and down the aisles of the classroom and use the name tents when interacting with students during structured student discussions. Forty-six students (34.6%) referenced in-class interactions with an instructor during lecture and 16 students (12.0%) mentioned interactions with an instructor during recitation as ways that instructors learned their name. The instructors of this course often arrived early to the classroom and would stay late to interact with students. Fifteen students (11.3%) reported that they thought their name was learned through interacting with an instructor before or after class. Lastly, a small subset of eight students (5.9%) mentioned that they thought their name was known because they sat near the front of the classroom.

Table 5.4

Student Perceptions of How Instructors Learned Their Name

Student perception of how instructors learned their name	% Responses of students with name known (n=133)	Example student response	Example student response
How students perceived names were learned inside the classroom			

Name tents	43.6%	"I was texting my mom one day in class and the instructor asked me to put my phone away. I think the instructor read my name tent at that moment and remembered me." – Holly	"The instructors were very persistent in using the yellow name tents and would use them whenever they had the chance. They made an effort to learn names by using the name cards." – Daniel
Interactions during class	34.6%	"By personally coming and talking to us during class participation (active learning) " – Arianne	"One instructor knows my name but I'm not sure why because, I always forget my name tent. She talks to me in class though, so maybe that's why" – Laura
Interactions during recitation	12.0%	"One instructor would come over during recitation and address me by my name. This happened a few times, which made it more personal rather than just reading it off a piece of paper." –Annie	"The instructor would talk to me in recitation and would remember who I am from those instances" – Kaylie
Interactions before or after class	11.3%	"Talk to and see the instructor before class" – Jorge	"One of the instructors took the time before class to talk to me once and see how my semester was going." – Bailey
Sitting near the front of the classroom	5.9%	"I sat up front on the very first day of class" – Eugene	"I sat at the front of the class most of the semester..." – Whitney
How students perceived names were learned outside the classroom			
Student attends office hours	33.1%	"I think the instructor knows my name because I have gone to his/her office hours a few times" – Dionne	"Because I visited the instructor's office to talk about exam scores, research, life, etc." – Ioulia
Email exchange between student and instructor	12.8%	"I email one instructor a lot and she/he hasn't blocked me yet, so guess that is a good thing." – April	"Probably knew my name from emails I sent the instructor." – Autumn
Student attends journal club for honors students	6.8%	"Yes, from class and from doing the honors journal club." – Shane	"By my participation in the honors [reading group]" – Jane
Extenuating circumstances	5.9%	"Reached out to one instructor near the beginning of the semester in order to reschedule an exam, had plenty of face-to-face interaction; has called me by name on	"At the beginning of the semester, I had frequent fainting spells right before the first exam- the instructors let me make-up the exam but not before a couple emails." – Erika

		future occasions" – Clay	
Student was previously known by an instructor	4.5%	"One instructor was originally on my camp for first-year students this past summer and was able to remember my name on the first day of class." – Donald	"I had one of the instructors as my instructor in a first-year seminar; on the first day, she recognized me" -Rodger

* Denotes a statistical difference ($p < 0.05$) between the percentage of students who perceived their names were known and were actually know by an instructor, and the percentage of students who perceived their names were known but were not actually known by an instructor.

Students also mentioned that instructors may have learned names through interactions that occurred outside of the classroom. For example, 44 students (33.1%) mentioned that they perceived that an instructor learned their names in office hours and 17 students (12.8%) responded that their name was learned through email exchanges with the instructors. Nine students (6.8%) reported that an instructor learned their name because of their participation in the course journal club that was available to honors students, and 6 students (4.5%) responded that the instructors already knew their name from previous interactions or events unrelated to this course. Additionally, 8 students (5.9%) reported that they experienced extenuating circumstances, such as a personal emergency, that required them to interact with an instructor, which caused the instructor to learn their name.

We also explored whether students who perceived that their names were known by an instructor when they actually were not, had similar responses as students whose names were actually known by an instructor. There were no significant differences among the ways that the two groups of students perceived that instructors learned their name with only one exception. A significantly greater percentage of students whose names were actually known by the instructor perceived that their names were learned in

office hours, compared to the number of students who perceived that their names were known, but were not actually known by the instructor ($p < 0.05$).

FINDING 4- NAME TENTS WERE USED BY INSTRUCTORS TO BUILD RELATIONSHIPS WITH STUDENTS, BUT ALSO USED BY STUDENTS TO BUILD RELATIONSHIPS WITH EACH OTHER

Notably, the highest percentage of students who perceived that their names were known reported that instructors learned their names by using name tents on the post-course survey. The instructors of this course purposefully implemented this practice in hopes of using student names as a way to create a more inclusive classroom community (K. D. Tanner, 2011, 2013b). We explored this instructional practice further with the student interviews to better understand students' perceptions of the name tents.

Student interview responses corroborated our post-course survey responses, which illustrated that students perceived that instructors used name tents to learn their names.

Interviewer: What is your opinion of the name tents?

Kaylie: I think the name tents are good just because the professor can learn your name. Even if you don't go to office hours, they'll learn your name.

Sam: I think the instructor learned my name from the name tents. I think they were probably pretty helpful. The instructors would come around and say "Hey [Sam], what do you think about this?" After a while I would imagine they just kind of learned my name without the name tent.

While we had anticipated that the name tents likely improved communication between instructors and students, we did not initially consider how the name tents would

influence communication among students. However, students found the name tents particularly useful when they were asked to interact with other students in this active learning classroom. For example, students such as Erika talked about how being called by their names improved communication between themselves and other students.

> Erika: I had my name tent out a couple weeks ago, and the person sitting next to me called me by my name. I turned around. It makes me respond better, because they call you by your name instead of like, 'Hey.' Some random person is talking to you, and they just want to discuss a worksheet question. When they call your name- I don't know what it is - it makes me want to have more communication with them, better communication since they call you by your name.

Other students talked about how they used the name tents to call other students by name. Courtney mentioned how she thinks that interactions with other students are more personal when you can call them by name.

> Courtney: Yes, [the name tents] are helpful because especially during the clicker questions when [the instructors] are like, 'Talk to your partner,' it's just easier if you know who you're talking to and you can call them by their name. It's just a better way to know people. It's more personal than just, "Hey, you."

Another student, Allen, talked about how, if a student answers a question during whole class discussions, the name tents can be used by everyone in the course to learn that student's name. He mentioned that using student names could help students to explore each other's understanding of biology content, or even to find a new study partner.

> Allen: [Using name tents] was interesting for everyone to be able to know you. Maybe if someone agreed with your idea, they could ask you to further your understanding. If someone disagreed, maybe they could come up to you later in recitation and say, 'This is what I think.' I think it was a good idea just to get to know people in an indirect way, so that if you thought someone had a good idea, that you can go up to you. Maybe you think that they might be a good study partner. Maybe you think they would be good in recitation. I think that sharing of ideas would be good.

One student, Kelsey, recognized that using other student names is a part of building classroom community. She implied that using name tents might be particularly helpful in active learning classrooms where students have more frequent interactions with other students.

> Kelsey: There's a girl that was in my breakout session and we worked during class and early on, once or twice I forgot her name and I would see her name tent, and even if I didn't use her name right then, I remember it now, and I'll probably continue to remember it. She's probably the closest thing I have to being a part of a biology community, just because we worked together so frequently. And knowing her name is part of building a community.

FINDING 5- SOME STUDENTS RESISTED NAME TENTS UNTIL THEY REALIZED THE BENEFITS OF HAVING THEIR NAME KNOWN OR LEARNING OTHER STUDENT NAMES

Historically, classroom practices focused on learning student names have been implemented in primary education (Page, n.d.) or in small-enrollment classrooms

(Zakrajsek, 2007). We were curious about students' reactions when name tents were first implemented in this large enrollment upper-level college class. In the student interviews, we asked students what they thought about using the name tents and whether their opinions changed over the course of the semester. Many students said that in the beginning of the semester they thought that they were childish and did not want to use them. They indicated that it was normal to be invisible in a high enrollment course and did not see the point in writing their name on a piece of cardstock. However, nearly all students that we interviewed reported that their opinions became more positive after they realized the benefits of either having their name used or using other student names. For example, Naomi talks about how she did not initially understand the purpose of the name tents, but eventually realized how name tents could be used to help build connections with others in class.

Interviewer: What was your opinion of the name tents at the beginning of the semester?

Naomi: In the beginning I was kind of 'OK, this is going to be awesome.

Interviewer: Sarcastically awesome?

Naomi: Yeah, it was sarcastically awesome because I wasn't expecting it and it was kind of like "Why would we have name tags in lecture? I don't really understand." Then after a while when you realize like 'Oh, [the instructors] know your name and it builds connections,' I actually liked the name tent. If I get another class that has name tents on the first day I would be more excited and it wouldn't be a sarcastic excitement, it would be an actual excitement. So yeah, names ended up being a good thing.

Similarly, Carolyn's opinion of the name tents became more positive once she realized that the name tents could be useful when engaging others in class discussion.

> Carolyn: At the beginning [of the course] I thought the name tents were silly just because there was really no point, and because I knew who I was going to sit with. But it helped engaging with groups nearby when you were going over clicker questions. It was helpful when I would try to engage with a group beside me, and I needed help with a question or I didn't know. I definitely would [use the name tents] if I couldn't get their attention, I would say one of their names.

Erika indicated that she began this course expecting that, because she was did not know anyone, no one would care what her name was. However, by the end of the course, she recognized that she was able to communicate with her peers better and even found a study partner because she was able to address another students by name.

> Erika: I didn't understand why [the instructors asked us to use name tents]. There are always big lectures, and no one really cares what your name is. I thought it was pointless. I thought it was like a first day thing. Then it was like, 'No, every day bring your name tents.' It was different. I didn't like it at first, but I think it's important. Just knowing someone else's name will help you talk to them better. I found a study partner for the first test. Just calling people by names instead of saying, 'Hey, want to study later?' I just feel like it's better to actually call people by name instead of just saying, "Hey."

Allen echoed that students are not just a face in the crowd when someone else in class knows their name and he grew to appreciate the benefit of getting to know others on a more personal level.

Allen: I thought they were childish at first, and maybe they still are, but I think that's a good way of developing understanding and putting a face to a name. We're not just another student. You're not just another 'whatever.' Not robotic, but more of getting to know people on a personal level. I think names are personal.

DISCUSSION

While instructors knowing student names is generally promoted as a positive and inclusive classroom practice (K. D. Tanner, 2011), to our knowledge there are no studies that explore how this specific instructional practice affects students. We set out to explore this question in the context of a large enrollment active learning undergraduate biology class.

Using student names: Important for classroom climate, especially in active learning classrooms. We found that the large majority of students (85%) felt as though instructors knowing their names was important. Students described that when instructors know their name, they feel more valued in the course and frequently mentioned that they feel as they are more than just a face in a crowd. This finding aligns with literature suggesting that knowing student names can help create an inclusive biology classroom(K. D. Tanner, 2013b).

Furthermore, this study suggests that using name tents may provide students with a more equitable experience in the classroom. Significantly fewer females reported that their names were likely to be known in previous large-enrollment biology courses which is in alignment with previous studies that show that females are less comfortable speaking out in large-enrollment biology classes (Eddy et al., 2014) and even when males

and females are equally outspoken, male students tend to be more memorable (Grunspan et al., 2016). In contrast, we found no gender differences in who perceived their names were known by instructors or whose names were actually known by instructors in this specific course. We hypothesize that the use of name tents may have contributed to the similar percentages of males and females who perceived that their names were known and whose names were actually known by instructors in this course.

As instructors continue to follow national calls to transition traditional lectures into active learning spaces (AAAS, 2011), students are being asked to interact with each other more frequently. More frequent social interactions among students during class have been shown to be correlated with students' higher sense of belonging, overall class enjoyment, and increased engagement during class (Sandstrom & Rawn, 2015). We found that students interacting with each other in this class use the name tents to improve communication and build community with other students. While previous research suggests that knowing student names is an important factor in building rapport between instructors and students (Lammers & Gillaspy, 2013; Wilson & Ryan, 2013), we are unaware of any studies that have explored how students using other student names influences community building among students. Our data suggest that students prefer more personal interactions with their peers and not only appreciate when other students call them by name, but also value the opportunity to address others by name. Interestingly, many students also mentioned that using other student names helped them to initiate or maintain friendships, as well as find study partners, which could have broader implications for student sense of belonging and retention in college (Sandstrom & Rawn, 2015; Tinto, 1975, 1997a).

Explicit instructor talk about using names and implementing name tents. The instructors of this course made a concerted effort to use student names as much as possible and to be explicit about why they were having students use the name tents. This Instructor Talk (Seidel et al., 2015) about the name tents at the beginning of the semester seemed to impact student perceptions of the practice in a positive way because instructors talked explicitly about using them to learn student names, to build community, and to help the instructors get to know students in a large class. The instructors of the course felt that they would have had less student buy-in if they had told students to use the name tents without being transparent about the purpose (Seidel & Tanner, 2013). Further, the instructors continuously reinforced the use of name tents. Students made them on the first day of class, but a reminder to set out the name tents was on the first slide of most class PowerPoints and the instructor verbally announced it as well in most class periods. Materials to make extra copies of name tents were provided at each lecture and this reinforcement was likely important for the students' continued use of name tents.

Using student names may influence student performance. Students reported that instructors knowing their name made them feel more comfortable approaching instructors for help and talking with instructors broadly or about subjects other than course material. Students who are more willing to seek help from instructors, particularly in large-enrollment courses, have been shown to be more motivated and perform higher on exams than students who are less likely to seek help (Karabenick, 2003). Furthermore, student-faculty interaction has been shown to positively predict students' grades and confidence in highly challenging college science courses (Micari & Pazos, 2012). These

findings align with students' perceptions in this study that having their name known by an instructor also improved their performance in the course.

While there is some evidence to suggest that immediate instructor behaviors may positively influence cognitive learning (Chesebro & McCroskey, 2001; Christophel, 1990; Kelley & Gorham, 1988; Titsworth, 2001) it is difficult to determine the specific impact of this instructional practice on student performance. Because we did not identify when in the semester students perceived that instructors learned their names (e.g. day one or the day before the final), we were unable to determine whether students who perceived their names were known performed better in the course than students who did not perceive their name was known. We hypothesize that it is important to account for the amount of time that a student suspected their name was known. Furthermore, pinpointing at what time point a student perceives their name is known would be necessary to determine directionality. For example, with our current data set it would be impossible to determine whether student perception of having their name known predicted office hour attendance or whether office hour attendance predicted student perception of having their name known. To begin to explore this question, we regressed students perceiving that their name was known at the end of the semester on overall exam performance in the course, controlling for prior GPA. We did not see any relationship between these two variables, but this is a coarse measure and a more reductionist approach is planned for future studies.

Instructors can have a positive influence on students, even when they do not actually know their names. Our data show that overwhelmingly, students are not used to having their names known in large enrollment biology courses, but that it is possible

for most students in large classes to perceive that an instructor knows their name. Importantly, this study suggests that instructors do not actually need to know a student's name in order for the student to perceive that their name is known. We feel that this is an encouraging finding for instructors tasked with teaching large enrollment courses, because it implies that, while instructors may be limited in the number of names they can learn, the number of students they can positively influence is not necessarily bounded. When instructors make an effort to use a student's name in class, students may perceive that an instructor knows their name when, in reality, the instructor is glancing at a student's name tent or worksheet for a reminder of the student's name. Anecdotally, the instructors of this course felt as though many students forgot that the name tents were visible to the instructors because name tents became a standard part of classroom practice. This may have contributed to why students perceived that instructors knew their name when they actually did not. Notably, any student who perceived that an instructor knew their name could experience a number of the benefits students mentioned including feeling more valued, more accountable to come to class, or more comfortable seeking help.

The effect of immediate instructor behaviors on student experiences in active learning. In this study we conclude that one verbal immediate instructor behavior, using student names, positively influences student experiences in an active learning classroom. However, additional studies are needed to explore the influence of other verbal and non-verbal immediate instructor behaviors on student affective and cognitive gains in active learning courses. Courses taught in an active learning way provide an important context in which to explore the effects of instructor immediacy. In traditional lecturing, there is

often a physical separation between instructors teaching at the front of the room and students passively listening in their seats. However, student-centered active learning affords additional opportunities for instructors to practice immediate behavior; instructors in active learning classroom often walk up and down the aisles in large lecture halls and engage students in conversation. In this course, instructors practiced immediate verbal behaviors, such as providing positive feedback to students, as well as non-verbal behaviors, such as walking around the classroom while students engaged in group work. We encourage future research efforts to take a reductionist approach to explore how specific immediate instructor behaviors could influence students in active learning classrooms.

Using student names: A low effort, high impact practice. While there are many things that instructors can do to create an inclusive and welcoming classroom (Tanner, 2011), using student names is a relatively simple practice that appears to positively affect students in multiple ways. In this course, many students reported that they perceived that their name was known through the use of name tents. Card stock costs approximately $20 for 250 sheets and name tents take about a minute for students to make. Instructors do not need special training to use name tents, nor does it take up much instructional time. This could be a relatively easy way for instructors to diminish the anonymity of large classrooms and simultaneously build community among students and between the instructor and students.

The second most prevalent way that students perceived that instructors learned their names was through office hours. The instructors of this course incentivized students to come to office hours by offering one point of extra credit (less than 0.1%) of their

overall grade. Thirty-two percent of students attended office hours, which likely also lead to the large number of students who perceived that their names were known by an instructor. Instructors may want to consider incentivizing students to attend office hours to increase the chances of students perceiving that their names are known. However, this practice puts the responsibility on the student to come to office hours, which may favor more outgoing or confident students.

CAVEATS

This is work conducted in the context of one class at a single institution. While the findings are encouraging, more research needs to be done to explore the impact of using student names in courses with a greater number of students, different classroom layouts, and different instructors.

This large enrollment course included 185 students, which we recognize is smaller than many other large-enrollment courses. It is possible that classes of 500+ students may be so large that students have much lower perceptions of instructors knowing their names, even if name tents are used.

Furthermore, the layout of a classroom likely influences instructor practices. In this course, instructors were able to move up and down aisles on both sides of the lecture classroom, which helped in seeing name tents and using student names. Instructors who are not able to freely move about the classroom may have a harder time reading name tents. However, an alternative strategy in a classroom without aisles is to not allow students to sit in some rows so that instructors are able to use that row to get closer to different groups of students.

The instructors of this course used a lot of Instructor Talk (Seidel *et al.*, 2015) to explain the purpose of the name tents and our data suggest that the instructors were generally perceived as approachable by students. Furthermore, the instructors of this course made the effort to be available to students before and after class, a practice that may not be possible for all instructors. Instructors with different immediate behaviors, personalities, and commitment to talking about name tents may lead to much different impacts on students. This needs to be replicated in classrooms taught by different instructors.

NEXT STEPS

This study is an exploratory study to see how, if at all, students are affected when they perceive that instructors know their names. Students in this study suggested that having their names known may influence student behavior such as attending office hours, asking questions, and coming to class. Further studies could explore whether student perception of instructors knowing their names actually influences these behaviors and performance in a course.

CONCLUSION

Does using a student's name in a large enrollment course matter? We have found that students perceive it is important for multiple reasons and that instructors do not even need to know student names for students to benefit. This student quote summarizes the potential impact of this relatively simple instructional practice on students in a large enrollment class:

Kelly: I know there are close to 200 kids in this class and I'm not in any way a top student or someone special, but I sure felt like I was when the instructor knew my name.

In contrast to what the student thought, the instructor did not know her name and had read her name off of the name tent. Yet, it was enough for this student to feel special in her large enrollment biology course.

REFERENCES

Chambliss, D. (2014). Learn your students' names. *Inside Higer Education*. Retrieved from Ed. www .insidehighered.com/views/2014/08/26/essay-calling-faculty-members -learn-their-students-names

Chesebro, J. L., & McCroskey, J. C. (2001). The relationship of teacher clarity and immediacy with student state receiver apprehension, affect, and cognitive learning. *Communication Education*, *50*(1), 59–68. https://doi.org/10.1080/03634520109379232

Christensen, L. J., & And Others. (1995). *Classroom Situations Which Lead to Student Participation*. Retrieved from https://eric.ed.gov/?id=ED391207

Christophel, D. M. (1990). The relationships among teacher immediacy behaviors, student motivation, and learning. *Communication Education*, *39*(4), 323–340. https://doi.org/10.1080/03634529009378813

Cooper, K. M., & Brownell, S. E. (2016). Coming Out in Class: Challenges and Benefits of Active Learning in a Biology Classroom for LGBTQIA Students. *CBE-Life Sciences Education*, *15*(3), ar37. https://doi.org/10.1187/cbe.16-01-0074

Eddy, S. L., Brownell, S. E., Thummaphan, P., Lan, M.-C., & Wenderoth, M. P. (2015). Caution, Student Experience May Vary: Social Identities Impact a Student's Experience in Peer Discussions. *CBE-Life Sciences Education*, *14*(4), ar45. https://doi.org/10.1187/cbe.15-05-0108

Eddy, S. L., Brownell, S. E., & Wenderoth, M. P. (2014a). Gender gaps in achievement and participation in multiple introductory biology classrooms. *CBE Life Sciences Education*, *13*(3), 478–492. https://doi.org/10.1187/cbe.13-10-0204

Eddy, S. L., Brownell, S. E., & Wenderoth, M. P. (2014b). Gender gaps in achievement and participation in multiple introductory biology classrooms. *CBE-Life Sciences Education*, *13*(3), 478–492.

Glaser, B. G., & Strauss, A. L. (2009). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Transaction Publishers.

Glaser, B. G., Strauss, A. L., & Strutzel, E. (1968). The Discovery of Grounded Theory; Strategies for Qualitative Research. *Nursing Research*, *17*(4), 364.

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction*. White Plains, NY: Longman.

Grunspan, D. Z., Eddy, S. L., Brownell, S. E., Wiggins, B. L., Crowe, A. J., & Goodreau, S. M. (2016). Males Under-Estimate Academic Performance of Their Female Peers in Undergraduate Biology Classrooms. *PLOS One*. https://doi.org/ttps://doi.org/10.1371/journal.pone.0148405

Karabenick, S. A. (2003). Seeking help in large college classes: A person-centered approach. *Contemporary Educational Psychology*, *28*(1), 37–58. https://doi.org/10.1016/S0361-476X(02)00012-7

Kelley, D. H., & Gorham, J. (1988). Effects of immediacy on recall of information. *Communication Education*, *37*(3), 198–207. https://doi.org/10.1080/03634528809378719

Lammers, W., & Gillaspy, J. A. (2013). Brief Measure of Student-Instructor Rapport Predicts Student Success in Online Courses. *International Journal for the Scholarship of Teaching and Learning*, *7*(2). https://doi.org/10.20429/ijsotl.2013.070216

Mehrabian, A. (1971). *Silent Messages*. Retrieved from https://www.scribd.com/doc/98446772/Albert-Mehrabian-Silent-Messages-1971

Menzel, K. E., & Carrell, L. J. (1999). The impact of gender and immediacy on willingness to talk and perceived learning. *Communication Education*, *48*(1), 31–40. https://doi.org/10.1080/03634529909379150

Micari, M., & Pazos, P. (2012). Connecting to the Professor: Impact of the Student–Faculty Relationship in a Highly Challenging Course. *College Teaching*, *60*(2), 41–47. https://doi.org/10.1080/87567555.2011.627576

Moore, A., Masterson, J. T., Christophel, D. M., & Shea, K. A. (1996). College teacher immediacy and student ratings of instruction. *Communication Education*, *45*(1), 29–39. https://doi.org/10.1080/03634529609379030

O'Sullivan, P. B., Hunt, S. K., & Lippert, L. R. (2004). Mediated Immediacy: A Language of Affiliation in a Technological Age. *Journal of Language and Social Psychology*, *23*(4), 464–490. https://doi.org/10.1177/0261927X04269588

Page, B. (n.d.). Teacher feature learning your student's names: fun, fast, easy, and important. Retrieved February 16, 2018, from https://www.teachers.net/gazette/AUG02/page2.html

Richmond, V. P., Gorham, J. S., & Mccroskey, J. C. (1987). The Relationship Between Selected Immediacy Behaviors and Cognitive Learning. *Annals of the International Communication Association*, *10*(1), 574–590. https://doi.org/10.1080/23808985.1987.11678663

Rocca, K. A. (2004). College student attendance: impact of instructor immediacy and verbal aggression. *Communication Education*, *53*(2), 185–195. https://doi.org/10.1080/03634520410001682447

Sandstrom, G. M., & Rawn, C. D. (2015). Embrace Chattering Students: They May Be Building Community and Interest in Your Class. *Teaching of Psychology*, *42*(3), 227–233. https://doi.org/10.1177/0098628315587620

Seidel, S. B., Reggi, A. L., Schinske, J. N., Burrus, L. W., & Tanner, K. D. (2015). Beyond the Biology: A Systematic Investigation of Noncontent Instructor Talk in an Introductory Biology Course. *CBE Life Sciences Education*, *14*(4), ar43. https://doi.org/10.1187/cbe.15-03-0049

Seidel, S. B., & Tanner, K. D. (2013). "What if students revolt?"—Considering Student Resistance: Origins, Options, and Opportunities for Investigation. *CBE Life Sciences Education*, *12*(4), 586–595. https://doi.org/10.1187/cbe-13-09-0190

Tanner, K. D. (2011). Moving Theory into Practice: A Reflection on Teaching a Large, Introductory Biology Course for Majors. *CBE Life Sciences Education*, *10*(2), 113–122. https://doi.org/10.1187/cbe.11-03-0029

Tanner, K. D. (2013a). Structure matters: twenty-one teaching strategies to promote student engagement and cultivate classroom equity. *CBE-Life Sciences Education*, *12*(3), 322–331.

Tanner, K. D. (2013b). Structure Matters: Twenty-One Teaching Strategies to Promote Student Engagement and Cultivate Classroom Equity. *CBE-Life Sciences Education*, *12*(3), 322–331. https://doi.org/10.1187/cbe.13-06-0115

Thomas, C. E., Richmond, V. P., & McCroskey, J. C. (1994). The association between immediacy and socio-communicative style. *Communication Research Reports*, *11*(1), 107–114. https://doi.org/10.1080/08824099409359946

Thweatt, K. (1999). The impact of teacher immediacy, teacher affinity-seek- ing, and teacher misbehaviors on student-perceived teacher credibility. Presented at the National Communication Association, Chicago, IL.

Tinto, V. (1975). Dropout from Higher Education: A Theoretical Synthesis of Recent Research. *Review of Educational Research*, *45*(1), 89–125. https://doi.org/10.3102/00346543045001089

Tinto, V. (1997). Classrooms as Communities. *The Journal of Higher Education*, *68*(6), 599–623. https://doi.org/10.1080/00221546.1997.11779003

Titsworth, B. S. (2001). The effects of teacher immediacy, use of organizational lecture cues, and students' notetaking on cognitive learning. *Communication Education*, *50*(4), 283–297. https://doi.org/10.1080/03634520109379256

Wilson, J. H., & Ryan, R. G. (2013). Professor–Student Rapport Scale: Six Items Predict Student Outcomes. *Teaching of Psychology*, *40*(2), 130–133. https://doi.org/10.1177/0098628312475033

Zakrajsek, T. (2007). Effective Teaching When Class Size Grows. *APS Observer*, *20*(5). Retrieved from https://www.psychologicalscience.org/observer/effective-teaching-when-class-size-grows

CHAPTER 6

TO BE FUNNY OR NOT TO BE FUNNY: GENDER DIFFERENCES IN STUDENT PERCEPTIONS OF INSTRUCTOR HUMOR IN COLLEGE SCIENCE COURSES

Students often perceive science courses to be difficult, competitive, and boring and science instructors have been stereotyped as dull and described as unapproachable (Armbruster, Patel, Johnson, & Weiss, 2009; Ebenezer & Zoller, 1993; Osborne & Collins, 2001; Seymour & Hewitt, 1997b; Strenta, Elliott, Adair, Matier, & Scott, 1994). Although these perceptions can be difficult to alter, one classroom practice that has the potential to positively change undergraduates' perceptions of science instructors and science classrooms is instructor use of humor.

Humor is commonly defined as the quality of being amusing or funny (Merriam-Webster, 2018). Although humor is subjective and it is often difficult to describe why something is funny, the research literature on humor suggests that what is often humorous is what is unexpected from the norm (Banas, Dunbar, Rodriguez, & Liu, 2011; Gervais & Wilson, 2005; Martin, 2010). People use humor for many different reasons (Banas et al., 2011) humor can be used to increase group cohesion (Banas et al., 2011; Kane, Suls, & Tedeschi, 1977; Martin, 2010; Provine, 2001) to relieve stress (Banas et al., 2011; Lynch, 2002), or to assert superiority (Banas et al., 2011; Lynch, 2002).

College instructors have been shown to regularly use humor during class (Bryant, 1980; Downs, Javidi, & Nussbaum, 1988; Javidi & Long, 1989). One study that sampled from 70 college courses across different academic disciplines found that 80% of instructors used humor at least once during a randomly selected 50-minute lecture (Bryant, 1980). For over 50 years, instructor humor has been recognized as a way to

positively impact student cognitive and affective learning [9,16–21]. For example, studies have shown that humor in the college classroom is positively related to student sense of community in the classroom (Torok, McMorris, & Lin, 2004), student attention during class (Neumann, Hood, & Neumann, 2009; Torok et al., 2004; Ulloth, 2002), student comfort asking questions of the instructor (Deiter, 2000), student participation in class (Goodboy, Booth-Butterfield, Bolkan, & Griffin, 2015) and student motivation to attend class (Deiter, 2000). Further, students self-report that humor improves their learning (Berk, 1996; Deiter, 2000), although research results conflict about whether humor actually enhances student learning. Some studies have found no relationship between humor and student learning (Bryant, Alan, Silberberg, & Elliott, 1981; Houser, Cowan, & West, 2007), while other studies have found that humor has a positive effect on student learning [9,24–26]. Notably, to our knowledge, no studies have explored the benefits of instructor humor specifically in the context of college science courses, which are often perceived as difficult and competitive (Armbruster et al., 2009; Ebenezer & Zoller, 1993; Osborne & Collins, 2001; Seymour & Hewitt, 1997b; Strenta et al., 1994).

The majority of studies that explore the effect of instructor humor on students have assumed that students perceived the humor to be funny, yet it is likely that students experience instructor humor that they perceive as unfunny or may even consider to be offensive. In fact, one study surveyed 124 students across three college classes about instructor use of humor and when students were asked to report possible problems with using humor in class, 32% of students identified that humor has the potential to be offensive (Torok et al., 2004) . Further, students in an introductory communications course generated 513 examples of instructor humor that they considered to be

inappropriate, many of which were disparaging to students (Wanzer, Frymier, Wojtaszczyk, & Smith, 2006). Even though there is evidence for what students perceive to be offensive or inappropriate forms of humor, to our knowledge no studies have explored how instructor use of offensive humor may influence students' experiences in the science classroom.

Further, there is some evidence that female students perceive certain subjects to be more offensive than male students. Studies have shown that female students are less tolerant of jokes about male or female stereotypes that are crude or profane (Sev'er & Ungar, 1997) and female students are less likely than male students to enjoy sexual humor (HERZOG, 2009). We do not know if women are more offended by topics of jokes that may be used by instructors in college science classrooms, nor do we know what impact offensive humor may have on the experience of women in science classes.

We do know however, that undergraduate women in college science courses have reported lower sense of belonging (Murphy, Steele, & Gross, 2007; Stout, Ito, Finkelstein, & Pollock, 2013; Townley et al., 2013), lower confidence (Hughes, 2000; MacPhee, Farro, & Canetto, 2013), and lower perception of their academic abilities compared to their male counterparts (KM Cooper, Krieg, & Brownell, Under review; Grunspan et al., 2016c; Hughes, 2000; MacPhee et al., 2013). Further, evidence suggests that women may be less engaged in science classes (Crombie, Pyke, & Silverthorn, 2003); specifically, studies show that, compared to males, females have a lower preference for being a leader in small group discussion (Eddy, Brownell, Thummaphan, Lan, & Wenderoth, 2015c) and do not participate as much in whole class discussion in college science courses (Eddy, Brownell, & Wenderoth, 2014d). Studies have also

shown that female STEM majors report significantly lower respect and recognition from STEM instructors (Hughes, 2000) and are less likely to perceive that instructors know their name (Katelyn M. Cooper, Haney, Krieg, & Brownell, 2017b). Notably, many of these gender disparities have been found across undergraduate science courses, even in disciplines such as biology where women make up 60% of undergraduate majors (Eddy & Brownell, 2016; Hughes, 2000; Lock, Hazari, & Potvin, 2013; MacPhee et al., 2013; Williams & George-Jackson, 2014). Could instructor use of humor be a factor negatively affecting the experience of women in college science courses?

In this manuscript, we set out to explore student perceptions of instructor use of humor in college science classrooms and whether there are any gender differences in how students perceive and are affected by instructor use of humor. The specific research questions of each study are as follows:

Study I: To what extent do students appreciate when instructors use humor in college science classes? Why do students appreciate when instructors use humor in college science classes?

Study II: How do instructors' use of funny humor, unfunny humor, and offensive humor in college science courses affect student attention to course content, instructor relatability, and student sense of belonging to the course? Are there gender differences in the extent to which students report being affected by funny, unfunny, and offensive humor?

Study III: When instructors use humor in college science classes, what potentially humorous subjects are students likely to find funny? What potentially

humorous subjects are students likely to find offensive? Are there potentially humorous subjects that male or female students are more likely to find funny or offensive?

METHOD AND RESULTS

This research project was conducted as part of a biology education course-based undergraduate research experience (CURE) taught by KMC, MEB, and SEB in the spring semester of 2017. A CURE is a course where students engage in novel, broadly relevant research (Auchincloss et al., 2014; Brownell & Kloser, 2015) . This course was backward designed with the goal of teaching students about biology education research by exploring a research question that could result in publication (Katelyn M. Cooper, Soneral, & Brownell, 2017). Sixteen students were enrolled in the semester-long 3 unit course. The instructors of the course and the student researchers collectively were responsible for developing the research questions, collecting data, analyzing data, interpreting data, and communicating the findings. See Cooper and Brownell (under review (Katelyn Cooper & Brownell, Under Review)) for a more detailed description of the structure and organization of this CURE.

HUMOR SURVEY DEVELOPMENT AND DISTRIBUTION

No previously developed survey existed to explore student perceptions of instructor use of humor in college science classrooms, so we designed a survey based on our specific research questions and the prior literature. We iteratively reviewed and modified the survey questions using a set of criteria that we developed to assess the appropriateness of each question (e.g. Is the question grammatically correct? Is the meaning and interpretation of the question clear? Are the question answer choices unambiguous in meaning? (Bowden, Fox-Rushby, Nyandieka, & Wanjau, 2002).

Seventeen researchers reviewed the survey and evaluated the appropriateness of survey questions based on the criteria (Bowden et al., 2002). The researchers provided written feedback about each question and the survey was revised. Next, three of the researchers (GVB, EAW, RJ**)** conducted a series of think-aloud interviews with a total of eight undergraduate biology students to establish cognitive validity of the humor survey by ensuring that students understood what each question was asking. The survey was iteratively revised after each think-aloud interview (Trenor, Miller, & Gipson, 2011b). Seventeen of the researchers completed the revised humor survey and again evaluated each question using the criteria for assessing survey questions. Once again, the survey was revised based on their feedback. Finally, the humor survey was piloted with one biology education post-doc, three biology education graduate students, and three undergraduate biology students, none of whom were involved with the project. The survey was revised a final time based on their feedback. Thus, the humor survey was iteratively revised a total of 11 times with 50 instances of individual feedback.

Data were collected from a large R1 institution in the Southwest United States. We recruited instructors to deploy the survey in their science classes. Instructors offered students a small amount of extra-credit for completing the ~15 minute survey. In cases where an instructor was not able to offer extra-credit, students were offered a chance to win a $200 gift card for completing the survey.

The survey was deployed using the online platform Qualtrics in 25 different undergraduate science classes, including courses in biology, chemistry, physics, and environmental science. Once instructors deployed the survey, students were given approximately one week to complete it. When all data were collected, student names

were immediately removed from survey responses and replaced with random identifiers. Two researchers (JMC and KM) cleaned the data by removing all entries from students who did not consent to participate in the study and from students who did not finish completing the survey. The researchers also deleted any duplicate responses from students who completed the survey more than once, leaving a complete set of 1637 student responses. Demographics of the students who consented to having their data included in the study are shown in Table 6.1.

Table 6.1

Demographics of Students Who Completed the Humor Survey

Demographic		% of Students (n = 1637)
Gender		
	Female	61.3%
	Male	36.8%
	Other	0.6%
	Decline to state	1.2%
Race/ ethnicity	American Indian, Native American, or Alaskan Native	0.5%
	Asian	14.6%
	Black or African American	4.2%
	Hispanic or Latino or Spanish	12.5%
	Native Hawaiian or Other Pacific Islander	0.5%
	White/Caucasian	49.8%
	Multiple races	11.7%
	Other	3.4%
	Decline to state	2.7%
Age		
	18-22	86.3%
	23-27	8.4%
	28-32	1.3%
	33+	1.6%
	Decline to state	2.3%
Major		
	Biological Sciences major	57.5%
	Chemistry or Biochemistry major	12.2%
	Engineering major	9.3%
	Other major (e.g. Psychology, Computer Science, Business)	19.1%
	Decline to state	1.9%

This study was done with an approved IRB protocol #00005725.

This study was conducted at an institution in the United States and we recognize that humor is highly dependent on culture and thus, these findings may not be translatable to non-Western cultures (Banas et al., 2011; Teslow, 1995).

STUDY I: TO WHAT EXTENT DO STUDENTS APPRECIATE WHEN INSTRUCTORS USE HUMOR IN COLLEGE SCIENCE CLASSES?. WHY DO

STUDENTS APPRECIATE WHEN INSTRUCTORS USE HUMOR IN COLLEGE SCIENCE COURSES?

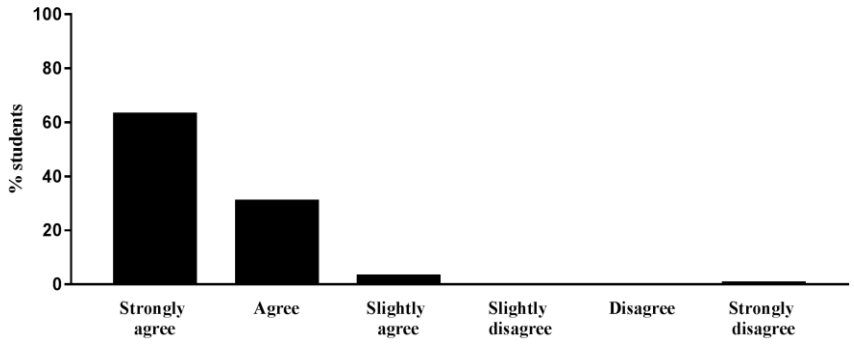
Study I Methods. To determine the extent to which students appreciate when instructors use humor in college science classes, we analyzed the survey question "Please indicate the degree to which you agree with the following statement: I appreciate when instructors use humor in college science classrooms," which students answered using a 6 point Likert-scale ranging from 1 = strongly disagree to 6 = strongly agree.

Students who strongly agreed, agreed, or slightly agreed that they appreciate when instructors use humor in college science classrooms were asked to explain their reasoning for why they appreciate when instructors use humor in college science classrooms. Four researchers (TH, ECL, AK, TR) reviewed student responses to this open-ended question using inductive coding (Creswell, 1994). We probed why students appreciate instructors' use of humor in undergraduate science courses without a specific hypothesis in mind because this question has never been explored in the context of undergraduate science courses. Thus, we did not want to bias our findings and we let themes emerge from the data (Corbin & Strauss, 2008). Together, the researchers analyzed a subset of 500 student responses and developed a rubric to describe the most apparent themes. Two researchers (KMC and SEB) reviewed the rubric and 200 student responses to ensure that the rubric was representative of the most apparent themes. Then, using the rubric, the four researchers (TH, ECL, AK, TR) individually analyzed 200 student responses using constant comparison methods (Corrine Glesne & Peshkin, 1992b). They assigned each quote to a theme and constantly compared quotes to each other to ensure that each quote fit within the description of the theme that it was assigned

to and to ensure that quotes were not different enough to warrant another category. A single student's response could consist of multiple quotes. After individually coding 200 responses, the researchers compared codes and revised the rubric. This process was repeated until there was a consensus estimate of at least 70% among all four researchers. Once reaching a consensus estimate of 70%, the four researchers individually used the rubric to code every student response. Finally, the researchers compared their codes for every student response and came to consensus when they disagreed.

Study I Results. The majority of students strongly agreed (63.7%), agreed (31.5%), or slightly agreed (3.7%) with the statement "I appreciate when instructors use humor in college science classrooms." Very few students strongly disagreed (0.4%), disagreed (0.2%), or slightly disagreed (0.5%) with the statement. Collapsing the data, 98.8% of students agreed and only 1.1% of students disagreed that they appreciate when instructors use humor in college science classrooms (Figure 6.1).

Figure 6.1. Student Responses to the Statement "I Appreciate When Instructors Use Humor in College Science Classrooms"



All students who agreed that they appreciate when instructors use humor in college science classrooms were asked why they appreciate when instructors use humor.

The inductive coding analysis generated nine themes. Of the 1618 students who reported that they appreciated humor, 1475 students (91.2%) provided a complete response to the question. All complete responses could be categorized under at least one theme. The nine themes were grouped into three larger categories: (1) humor positively changes the classroom environment, (2) humor improves students' experiences in class, and (3) humor enhances the relationship between students and the instructor. Students were able to write as much as they wanted in response to this question and 1139 students (77.2% of students who provided complete responses) reported more than one reason for why they appreciate when instructors use humor in college science classrooms. The average number of reasons that a student reported was 1.62. The percent of responses that fell into a particular category is calculated by dividing the number of responses by the number of students who provided a complete response (n = 1475).

Students reported that they appreciate when instructors use humor in college science classes because it positively changes the classroom atmosphere (**Table 2**). Specifically, 49.4% of students appreciate science instructors' use of humor because it makes class more interesting, fun, or exciting and makes the class feel less boring. Students (21.8%) also described how science classes can feel "dark" or "heavy" and when science instructors use humor, it lightens the mood of the class and creates a more comfortable and inviting environment. Further, students (7.8%) acknowledged that science content can be difficult and when instructors use humor, it gives students a break from the hard content and allows for more time to process difficult information.

Table 6.2

Students Appreciate Instructors' Use of Humor in College Science Classrooms for Nine Distinct Reasons

Theme	Description of theme	% Responses (n = 1475)	Example student quote	Example student quote
Humor positively changes the classroom atmosphere				
Makes class more interesting, fun, or exciting	Student indicates that when instructors use humor in college science classes it makes class more interesting, fun, exciting, entertaining, enjoyable, engaging, or less boring.	49.4%	"When humor is used in class it just makes the time more fun and enjoyable rather than just listening to someone speak for an hour and a half about science."	"I find that humor helps to make classes more enjoyable in general and that one simple laugh can help put you in the right mood for the rest of the day, which is especially helpful when you're a science major with organic chemistry at 7:30am."
Lightens the mood of class	Student indicates that when instructors use humor in college science classes it lightens the mood of the class, makes the atmosphere friendlier, more relaxed, more comfortable, more inviting, or less intimidating.	21.8%	"Science is very black and white, and it is nice to lighten the mood of the classroom sometimes."	"Humor brings an air of lightness into the lecture. Not so heavy."
Gives students a break from hard content	Student indicates that when instructors use humor in college science classes it gives them a break from difficult science content, allows them time to process the material, or breaks up a lot of information.	7.8%	"When instructors use humor in class, I feel like it gives the students a moment of relief or laughter that is mostly never seen in the dense material covered in science courses."	"Typically the information we learn is sometimes hard to understand, so when humor is used, our brains get a brief break to re-group before learning more hard stuff."
Humor improves students' experience during class				
Engages students during class	Student indicates that when instructors use humor in college science classes it changes students' behavior causing them to listen more, pay more attention, be more involved, be	26.5%	"I appreciate when an instructor uses humor in class because it can help keep students engaged in the topics especially when the class is nearing a close."	"For me, humor in any class increases my attention level and my willingness to participate in the class. I think it's more important to do for science class

	more present, be more engaged, or focus on the material.			because the material can be very dry and repetitive, so any comedic relief is nice."
Enhances student learning	Student indicates that when instructors use humor in college science classes they learn more in class or that humor helps students remember, retain, recall, or understand content.	21.4%	"Humor makes points and concepts in class easier to remember/memorize"	"When instructors use humor during any class, it allows me to connect more to the info (…) Maybe I remember a joke or something they said that helps me remember the info."
Reduces stress-related emotions about class	Student indicates that when instructors use humor in college science classes it causes students to feel more calm or less anxious, nervous, stressed, or tense about learning science content or about the class broadly.	8.5%	"It takes away a bit of the stress that we have when we're learning something in class that might be difficult for us to understand."	"Science is one of the harder subjects to be found on a college course list, and with this comes a lot of stress and anxiety, so when a teacher takes the time to joke around, it takes some of the edge off."
Humor enhances relationships between students and instructors				
Makes the instructor more relatable or personable	Student indicates that when instructors use humor in college science classes it makes the instructor more relatable, more personable, more human, or the student feels like they have more in common with the instructor.	13.3%	"When my professors use humor, it makes them more relatable. Using humor also makes them more 'real' to me."	"I appreciate when instructors use humor in the classroom because it's a reminder they are people just like us."
Makes the instructor more approachable	Student indicates that when instructors use humor in college science classes it makes students feel less intimidated, more comfortable, or less nervous approaching the instructor.	7.6%	"By using humor, the instructors seem to be more approachable. Therefore, I am more likely to approach them and ask them questions after class."	"The professor using humor helps me feel comfortable enough with the professor so that I can ask questions."
Builds a relationship between the instructor and the student	This category extends beyond relating to or approaching the instructor. Student indicates that the distance between instructor and student is decreasing or	5.5%	"When a professor is funny or tells a lot of jokes, it helps break down the barriers between students and professors that prevent	"I think that it creates a better relationship between the students and the teacher."

	indicates that there is a connection or bond being built between the student and instructor.	the two from forming a better relationship."

Students also highlighted that humor improves students' experiences during class. For example, 26.5% of students described that when science instructors use humor, it can cause students to pay more attention in class or to be more engaged with the material and 21.4% of students perceived that humor helps them retain science content and can even enhance their learning. Additionally, students (8.5%) described that science classrooms can cause them to feel stressed or anxious, but instructor use of humor can reduce students' stress related emotions about the class.

The final overarching category that emerged from the data was that instructor use of humor can enhance the relationship between the instructor and the student. Students (13.3%) described that when science instructors use humor it makes the instructor more personable or relatable and helps students realize that the instructor is a "real person." In fact, some students (7.6%) perceive that when instructors use humor they appear more approachable and students are more likely to go to them for help or advice. Lastly, students (5.5%) perceived that science instructors' use of humor can go beyond making the instructors seem more personable and approachable and help build a relationship between instructors and students.

Study I Conclusion. Nearly all students (98.8%) appreciate when instructors use humor in college science classrooms. Students appreciate science instructors' use of humor because it positively changes the classroom atmosphere, improves student experiences in class, and enhances the relationship between students and the instructor.

STUDY II: HOW DO INSTRUCTORS' USE OF FUNNY HUMOR, UNFUNNY HUMOR AND OFFENSEIVE HUMOR IN COLLEGE SCIENCE COURSE SAFFECT STUDENT ATTENTION TO COURSE CONTENT, INSTRUCTOR RELATABILIYT, AND STUDENT SENSE OF BELONGING TO THE COURSE? ARE THERE GENDER DIFFERENCES IN THE EXTENT TO WHICH STUDENTS REPORT BEING AFFECTED BY FUNNY, UNFUNNY, AND OFFENSIVE HUMOR?

In general, the use of humor has been shown to positively impact students. However, while instructors likely intend for students to find their humor funny, instructors' use of humor in college science classrooms may not be perceived by all students as funny, and some humor may even be perceived by students as offensive. Yet, no prior study has explored how instructor humor that students perceive to be unfunny or offensive affects students in science courses. Thus, we were interested in exploring the impact of funny, unfunny, and offensive humor on student experiences in class. Further, we tested whether there were gender differences in the extent to which funny, unfunny, and offensive humor impacts student attention to course content, instructor relatability and student sense of belonging to the science course. We acknowledge that gender identity is not binary (male/female) and recognize that some students identify with non-binary gender identities. Unfortunately, there were too few students who identified as non-binary to include them in the gender analyses in this study.

Study II Methods. On the humor survey, students were asked to provide an example of a time that an instructor used humor in a college science course and they thought that it was funny (n = 1637). Then, students were asked how their example of

the instructor's use of funny humor affected their attention to course content, which they answered on a 5-point Likert scale: 1 = It made me pay a lot less attention to course content, 2 = It made me pay a little less attention to course content, 3 = It did not affect my attention to course content, 4 = It made me pay a little more attention to course content, 5 = It made me pay a lot more attention to course content. Students were also asked how their example of the instructor's use of funny humor influenced instructor relatability, which they answered on a 5-point Likert scale: 1 = It made the instructor a lot less relatable, 2 = It made the instructor a little less relatable, 3 = It did not affect how relatable the instructor was to me, 4 = It made the instructor a little more relatable, 5 = It made the instructor a lot more relatable. Finally, students were asked how their example of the instructor's funny use of humor affected their sense of belonging to their science class, which they answered using a 5-point Likert scale: 1 = It made me feel like I belonged to the class a lot less, 2 = It made me feel like I belonged to class a little less, 3 = It did not affect my sense of belonging to the class, 4 = It made me feel like I belonged to class a little more, 5 = It made me feel like I belonged to the class a lot more.

Next, students were asked to provide an example of a time that an instructor used humor in a college science course and they did *not* find it funny. After students provided the example that they did not think was funny, they were asked whether they perceived the example of instructor humor as offensive (1411 students provided an unfunny example that they did not perceive as offensive (unfunny humor) and 159 students provided an unfunny example that they perceived as offensive (offensive humor)). Then, using the same format of questions described above, students were asked to report how the example of an instructor's use of humor that they did not find funny affected their

attention to course content, instructor relatability, and their sense of belonging to the class.

We used multinomial logistic regression to determine whether there were gender differences in the extent to which students reported that funny, unfunny, and offensive humor affected their attention to course content, instructor relatability, and sense of belonging to the course. Multinomial logistic regression is an approach for modeling the relationship between more than two categorically distributed dependent variables- in this case, whether a student reported that a type of humor had a positive impact, no impact, or a negative impact on an outcome variable (student attention to course content, instructor relatability, and sense of belonging to the class) and predictor variables, in this case, student gender. For each type of instructor humor- funny, unfunny, and offensive- we ran three multinomial models to explore the effect of that particular type of instructor humor on students' reported attention to course content, instructor relatability, and sense of belonging to the class, respectively. Each multinomial model consists of a set of two independent binary logistic regression models. We provide the results of each regression by listing the focus category followed by the reference category and the respective p-value (e.g. focus category/reference category, p-value). There are several ways to interpret model coefficients from logistic regression; the most accessible way is to interpret the natural exponential of the estimated coefficient, which is the factor of change in odds that females compared to males will report that humor affected them in a particular way (e.g. did not affect their sense of belonging vs. increased their sense of belonging), also referred to as the "odds ratio". The odds ratio can be considered a

standardized effect size statistic because the explanatory variable, gender, is binary (Agresti & Franklin, 2012; Deeks, 1998).

Study II Results.

Attention to course content. We found that the majority of students reported that an instructor's use of funny humor caused them to pay either a little more (39.0%) or a lot more (49.2%) attention to course content. For 11.1% of students, an instructor's use of funny humor did not affect their attention to course content and for less than 1% of students, it caused them to pay attention to course content less (Fig 6.2A). Females were not significantly more likely than males to report that funny humor makes them pay more attention to course content (more attention/less attention, $p = 0.85$; more attention/no effect, $p = 0.23$). All model coefficients, z values, p values, and significant odds ratios are listed in Table 6.3.

Figure 6.2**.** A. Student perception of how instructor use of funny, unfunny, and offensive humor affect their attention to course content. B. Student perception of how funny, unfunny, and offensive humor affect instructor relatability. C. Student perception of how funny, unfunny, and offensive humor affect their sense of belonging to the course.

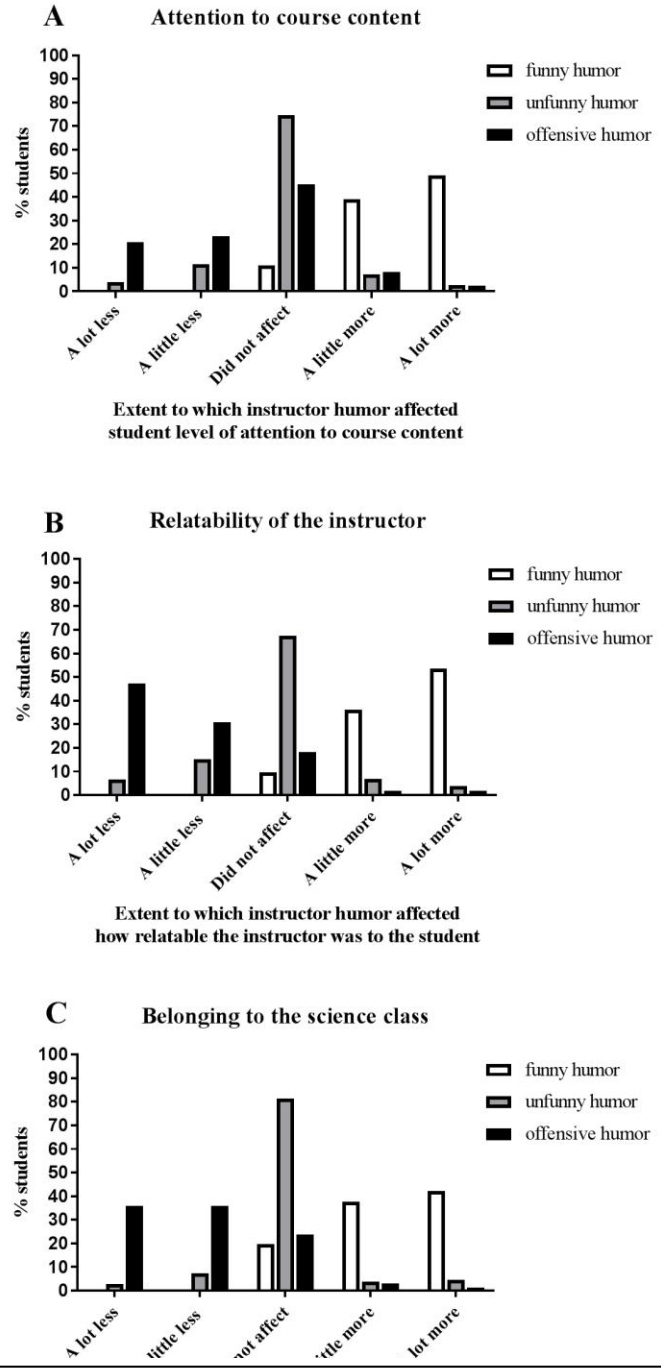


Table 6.3

Multinomial Regression Coefficients for Models Used to Determine Whether There are Gender Differences in the Extent to Which Funny, Unfunny, and Offensive Humor Affects Students

		Intercept β±CI (z-value, p-value)	Gender: female (ref:male) β±CI (z-value, p-value)	Standardized effect size- odds ratio that females compared to males will report that humor affected their attention in a specific way
Dependent variable = Student attention to course content				
Funny humor (n = 1637)	Increased attention (ref: No effect)	1.97 ± 0.24 (z = 15.83, p = 0.00)	0.19 ± 0.31 (z = 1.20, p = 0.23)	
	Increased attention (ref: Decreased attention)	4.88 ± 0.98 (z = 9.73 p = 0.00)	0.12 ± 1.27 (z = 0.19, p = 0.85)	
Unfunny humor (n = 1411)	No effect (ref: Increased attention)	1.76 ± 0.50 (z = 13.56, p = 0.00)	0.49 ± 0.35 (z = 2.69, p = 0.007)	Females are 1.6x more likely than males to report that unfunny humor has no effect on attention to course content compared to reporting that it increased their attention.
	No effect (ref: Decreased attention)	1.71 ± 0.25 (z = 13.48, p = 0.00)	-0.22 ±0.31 (z = -1.42, p =0.15)	
Offensive humor (n = 159)	No effect (ref: Increased attention)	1.16 ± 1.00 (z = 2.27, p = 0.02)	0.22 ± 0.78 (z = 0.37, p = 0.71	
	No effect (ref: Decreased attention)	0.06 ± 0.69 (z = 0.17, p = 0.86)	-0.08 ± 0.78 (z = -0.20, p =0.84)	
Dependent variable = Instructor relatability				
Funny humor (n = 1637)	Increased relatability (ref: No effect)	2.11 ± 0.25 (z = 16.08, p = 0.00)	0.22 ± 0.33 (z = 1.31, p = 0.19)	
	Increased relatability (ref: Decreased relatability)	2.79 ± 1.00 (z = 5.41 p = 0.00)	0.81 ± 1.51 (z =-1.07, p = 0.29)	
Unfunny humor (n = 1411)	No effect (ref: Increased relatability)	1.43 ± 0.24 (z = 12.00, p = 0.00)	0.82 ± 0.35 (z = 4.54, p = < 0.001)	Females are 2.3x more likely than males to report that unfunny humor has no effect on instructor relatability compared to reporting that it increased

				instructor relatability.
	No effect (ref: Decreased relatability)	1.31 ± 0.22 (z = 11.50, p = 0.00)	-0.27 ± 0.27 (z = -1.91, p = 0.06)	
Offensive humor (n = 159)	Decreased relatability (ref: Increased relatability)	1.83 ± 1.06 (z = -3.40, p = 0.00)	2.72 ±2.23 (z = 2.34, p = 0.02)	Females are 15.2x more likely than males to report that offensive humor decreased instructor relatability compared to reporting that it increased instructor relatability.
	Decreased relatability (ref: No effect)	-1.02 ± 0.76 (z = -2.63, p = 0.01)	-0.59 ± 0.90 (z = -1.27, p = 0.20)	
Dependent variable = Student sense of belonging to the course				
Funny humor (n = 1637)	Increased sense of belonging (ref: No effect)	1.35 ± 0.20 (z = 13.44, p = 0.00)	0.09 ± 0.25 (z = 0.67 p = 0.50)	
	Increased sense of belonging (ref: Decreased sense of belonging)	11.90 ± 34.38 (z = 0.68, p = 0.50)	-5.19 ± 34.4 (z = -0.29, p = 0.77)	
Unfunny humor (n = 1411)	No effect (ref: Increased sense of belonging)	1.77 ± 0.25 (z = 14.09, p = 0.00)	1.01 ± 0.39 (z = 5.00, p = < 0.001	Females are 2.7x more likely than males to report that unfunny humor has no effect on their belonging compared to reporting that it increased their belonging.
	No effect (ref: Decreased sense of belonging)	2.36 ± 0.31 (z = 14.46, p = 0.00)	-0.40 ± 0.39 (z = -2.03, p = 0.04)	Females are 1.5x less likely than males to report that unfunny humor has no effect on their belonging compared to reporting that it decreases their belonging.
Offensive humor (n = 159)	Decreased belonging (ref: Increased belonging)	1.57 ± 0.96 (z = 3.40, p = 0.00)	2.18 ± 1.71 (z = -2.39, p = 0.01)	Females are 8.8x more likely than males to report that offensive humor decreased belonging compared to reporting that it increased their belonging.
	Decreased belonging (ref: no effect)	0.98 ± 0.76 (z = 2.51, p = 0.00)	0.13 ± 0.88 (z = 0.29, p = 0.77)	

The majority of students (74.6%) reported than an instructor's use of unfunny humor did not affect their attention to course content. However, for nearly 16% of students, an instructor's use of unfunny humor caused them to pay a little less (11.6%) or a lot less (4.0%) attention to content. For some students, even though they found an instructor's use of humor unfunny, it still caused them to pay attention to the content either a little more (7.2%) or a lot more (2.7%) (Figure 6.2A). Females were 1.6x more likely than males to report that unfunny humor had no effect on their attention compared to reporting that it made them pay more attention (no effect/more attention, $p = 0.007$). However, there was no significant gender difference in the extent to which students reported that unfunny humor had no effect on their attention when compared to causing them to pay less attention (no effect/less attention, $p = 0.15$).

For many students, if the instructor's use of humor was offensive to them, it negatively influenced their attention to course content, as 23.3% of students described that an instructor's use of offensive humor caused them to pay attention to course content a little less and 20.8% of students described that it caused them to pay attention a lot less. For 45.3% of students, an instructor's use of offensive humor did not affect their attention to course content. There were some students who, despite finding the instructor's use of humor offensive, reported that it made them pay attention to course content either a little more (8.2%) or a lot more (2.5%) (Figure 6.2A). Females were no more or less likely than males to report that offensive humor had no effect on their attention to course content (no effect/less attention, $p = 0.84$, no effect/more attention, $p = 0.71$).

Instructor relatability. On average, an instructor's use of funny humor in college science classes increased instructor relatability for students. The majority of students reported that an instructor's use of funny humor made the instructor either a little more relatable (36.2%) or a lot more relatable (53.7%). While 9.5% of students reported that the instructor's use of funny humor did not affect how relatable the instructor was to the student, less than 0.5% of students reported that it made the instructor less relatable to them (Figure 6.2B). Females were not significantly more likely than males to report that funny humor makes the instructor more relatable (more relatable/no effect, $p = 0.19$, more relatable/less relatable $p = 0.29$).

For most students (67.5%), an instructor's use of unfunny humor did not affect how relatable the instructor of the course was to them. However, some students reported that an instructor's use of unfunny humor made the instructor a little less relatable (15.2%) or a lot less relatable (6.5%). Interestingly, about 10% of students reported that even when they did not find an instructor's use of humor funny, it still made the instructor seem a little more relatable (7.0%) or a lot more relatable (3.8%) (Figure 6.2B). Females were 2.3x more likely than males to report that unfunny humor had no effect on their instructor relatability compared to a positive impact (no effect/more relatable, $p< 0.001$). However, there was no significant gender difference in the extent to which students reported that unfunny humor had no effect on instructor relatability compared to a negative impact (no effect/less relatable, $p = 0.06$).

If the instructor's use of unfunny humor was offensive, the majority of students reported that it made the instructor a little less (30.8%) or a lot less (47.2%) relatable. For 18.2% of students, the instructor's offensive humor did not affect how relatable the

instructor was for the student, and a minority of students (3.8%) reported that although they perceived the instructor's humor as offensive, it made the instructor more relatable to the student (Figure 6.2B). Females were 15.2x more likely than males to report that offensive humor made the instructor of the course less relatable compared to more relatable (less relatable/more relatable, $p = 0.02$). However, there was no significant gender difference in the extent to which students reported that offensive humor made the instructor of the course less relatable compared to having no effect on instructor relatability (less relatable/no effect, $p = 0.20$).

Sense of belonging. We were also interested to see how instructor use of humor affects students' sense of belonging to the course. On average, instructors using funny humor increased students' belonging to their science class; instructor use of funny humor increased most students' sense of belonging to the course a little more (37.8%) or a lot more (42.2%). For 19.8% of students, the instructors' use of funny humor did not affect their sense of belonging and only 0.2% of students reported that the funny example caused them to feel as though they belonged to class less (Figure 6.2C). Females were not significantly more likely than males to report that funny humor makes them feel as though they belong more to the class (belong more/no effect, $p = 0.50$, belong more/belong less, $p = 0.77$).

On average, science instructors' use of unfunny humor did not seem to influence students' sense of belonging to their science class. The majority of students (81.4%) reported that instructors' use of unfunny humor did not affect their sense of belonging. There was no clear trend for how instructors' use of unfunny humor affected the remaining students; less than 10% of students reported that an instructor's use of unfunny

humor caused them to feel like they belonged to class a little more (3.8%) or a lot more (4.5%) and approximately 10% of students reported that the instructor's use of unfunny humor caused them to feel like they belonged to class a little less (7.4%) or a lot less (2.9%)**.** Females are 2.7x more likely than males to report that unfunny instructor humor has no effect on their belonging compared to a positive impact (no effect/belong more, $p < 0.001$). However, females are 1.5x less likely than males to report that unfunny humor has no effect on their belonging compared to a negative impact (no effect/belong less, $p = 0.04$).

When students perceived the instructors' use of unfunny humor to be offensive, it was more likely to negatively affect their sense of belonging. While 23.9% of students reported that an instructor's use of offensive humor did not affect their sense of belonging to the course, 35.9% of students reported that it made them feel like they belonged to the class a little less and 35.9% of students reported that it made them feel like they belonged to the class a lot less (Figure 6.2C**)**. Females are 8.8x more likely than males to report that offensive humor caused them to feel as though they belong less to the course compared to reporting that offensive humor makes them feel as though they belong more to the course (belong less/belong more, $p = 0.01$). However, there was no significant gender difference in the extent to which students reported that offensive humor made them feel as though they belong less to the course when compared to reporting that offensive humor had no effect on their sense of belonging (belong less/no effect, $p = 0.77$).

Study II Conclusion. Instructors' use of humor that students found funny positively affected the majority of students' attention to course content, instructor relatability, and students' sense of belonging to the course. Instructors' use of humor that

students did not find funny did not have an impact on most students' attention to course content, instructor relatability, or students' sense of belonging to the class. However, if students considered an instructor's unfunny example of humor to be offensive, for most students, it negatively influenced their sense of belonging to the course and the instructor's relatability. For most students, offensive humor either did not have an effect on their attention to course content or caused them to pay less attention to course content.

There were few gender differences in how funny, unfunny, and offensive humor affected student-reported attention to course content, instructor relatability, and sense of belonging to the course. This suggests that females and males have similar reactions to humor that they find funny and that they have similar reactions to humor that they find offensive. The differences that were observed indicated that females were more likely than males to report that unfunny humor did not affect them compared to reporting that it had a positive effect on their attention, instructor relatability, or sense of belonging. This isn't necessarily surprising because very few students reported that unfunny instructor humor affected them positively and these students were mostly male. Similarly, female students were more likely than males to report that offensive humor had a negative impact on their attention and instructor relatability compared to reporting a positive impact. Once again, very few students reported that offensive humor positively affected them and those who did were mostly male.

STUDY III: WHEN INSTRUCTORS USE HUMOR IN COLLEGE SCINECE CLASSES, WHAT POTENTIALLY HUMOROUS SUBJECTS ARE STUDENTS LIKELY TO FIND FUNNY? WHAT POTENTIALLY HUMOROUS SUBJECTS ARE STUDENTS LIKELY TO FIND OFFENSIVE? ARE THERE

POTENTIALLY HUMOROUS SUBJECTS THAT MALE OR FEMALE STUDENTS ARE MORE LIKELY TO FINF FUNNY OR OFFENSIVE?

Given the positive impact of funny instructor humor on students in science classrooms and the negative impact of offensive humor on students in science classrooms, it would be helpful to know what potentially humorous subjects students are most likely to find funny and offensive if joked about by an instructor in the context of a college science course.

Study III Methods. We were interested if a college science instructor were to tell a joke, what potentially humorous subjects students might find funny or offensive. To identify common potentially humorous subjects, 16 researchers interviewed a convenience sample of 95 college students about the last funny joke that they heard and the last offensive joke that they heard. These were not necessarily jokes told by an instructor in class, but jokes that the student had heard most recently. Two researchers (KMC and SEB) reviewed all 190 examples (95 examples of funny humor and 95 examples of offensive humor), recorded the subject of each joke, and created a list of 34 unique subjects that were mentioned by at least three college students. The interviews of college students took place in February 2017, shortly after the 2017 United States presidential inauguration, which was reflected in the subjects that were recorded. We chose to include all subjects even if they were specific to a particular time or event.

We included the list of 34 potentially humorous subjects on the humor survey that was sent out to students in college science courses. On the humor survey, students were presented with the list of 34 potentially humorous subjects and asked "If a college science instructor were to tell a joke in class, which of the following jokes might you find

funny? Please select all that you might find funny." For the next question, students were presented with the same list of 34 potentially humorous subjects and asked "If a college science instructor were to tell a joke in class, which of the following jokes might you find offensive? Please select all that you might find offensive." The question explicitly asked students about "jokes" but the responses were phrased with a focus on the joke subject (e.g. jokes about dogs, jokes about politics).

Given prior research that shows that females and males can interpret humor differently (HERZOG, 2009; Sev'er & Ungar, 1997), we were interested in exploring whether there were differences in the subjects that females and males find funny and offensive when joked about by an instructor in the context of a college science course. We used logistic regression to determine whether there were gender differences in what subjects students report that they might find funny and offensive. Logistic regression is an approach for modeling the relationship between a dependent variable with two categories, such as whether a student perceives a subject to be funny or not- and an explanatory variable, such as gender. Because there were 34 comparisons for subjects that students might find funny, and 34 comparisons for subjects students might find offensive, we applied the Bonferroni correction for significance at the $p < 0.05$ level for each set of comparisons. The Bonferroni-adjusted p-value needed for significance is $p < 0.001$. All p-values for logistic regressions exploring funny subjects and all odds ratios for analyses assessing gender differences in funny humor are listed in Table 6.5. All p-values for logistic regressions exploring offensive subjects and all odds ratios for analyses assessing gender differences in offensive humor are listed in Table 6.6.

Study III Results. The 34 potentially humorous subjects that emerged from student interviews could be categorized as subjects related to United States politics (6 subjects: politics, Republicans, Democrats, Donald Trump (the 45th President of the United States), Hillary Clinton (the 67th US Secretary of State and the Democratic Party's nominee for the President of the United States in 2016), Sean Spicer (served as the White House Press Secretary in 2017)), subjects related to sex or bodily functions (3 subjects: sex, genitalia, farts/poop), subjects related to entertainment (2 subjects: television, sports), subjects related to relationships (2 subjects: relationships, divorce), subjects related to college (2 subjects: college, students), subjects related to animals (3 subjects: cute animals, dogs, cats), and subjects related to social identities (13 subjects: old people, women, Mormons, Christians, Catholics, Mexicans, Immigration/Immigrants, Jewish people, African Americans, gay or lesbian people, Muslims, transgender people, people with disabilities). Social identities provide individuals with a sense of who they are and they are based on group memberships. Three subjects could not be organized into a larger category: science, food puns, and weight. (Table 6.4).

Table 6.4

The Percent of Students Who, if a Science Instructor Were to Tell a Joke About a Specific Subject, Might Find the Joke Funny and Might Find the Joke Offensive

Potentially humorous subjects	% students who might find jokes about subject funny if told by a science instructor	% students who might find jokes about subject offensive if told by a science instructor
Science	**89.3%**	**1.5%**
College	**84.7%**	**1.5%**
Television	**75.9%**	**1.3%**
Food puns	67.3%	1.5%
Relationships	62.3%	8.8%
Cute animals	55.9%	3.6%
Dogs	55.7%	4.5%
Cats	53.2%	3.4%
Sports	51.7%	4.0%
Students	51.5%	16.3%
Politics	48.5%	16.4%
Donald Trump	45.9%	17.2%
Sex	43.9%	18.9%
Farts or poop	33.3%	11.4%
Hillary Clinton	27.5%	23.3%
Old people	27.3%	29.6%
Genitalia	23.4%	33.8%
Republicans	23.2%	35.2%
Divorce	21.6%	28.2%
Sean Spicer	20.8%	13.9%
Democrats	20.6%	39.7%
Women	16.2%	61.6%
Weight	15.8%	48.1%
Mormons	15.5%	45.2%
Christians	15.0%	51.1%
Catholics	12.9%	49.5%
Mexicans	12.2%	60.6%
Immigration/Immigrants	12.0%	49.4%
Jewish people	11.2%	57.1%
African Americans	10.8%	60.9%
Gay or lesbian people	10.4%	58.8%
Muslims	10.1%	62.4%
Transgender people	10.0%	59.9%
People with disabilities	8.2%	63.7%

Note. The table is organized by subjects that the largest percent of students might find funny to subjects that the smallest percent of students might find funny. Subjects that the majority of students might find funny are highlighted in light grey. Subjects that the majority of students might find

offensive, which are all subjects related to social identities, are highlighted in dark grey. Subjects that at least 75% of students find funny and that may be considered relatively inoffensive because less than 2% of students report that they might find the subject offensive, are bolded.

At least half of the students surveyed reported that, if a science instructor told a joke, they might find the joke funny if it were about science (89.3%), college (84.7%), television (75.9%), food puns (67.3%), relationships (62.3%), cute animals (55.9%), dogs (55.7%), cats (53.2%), sports (51.7%), and students (51.5%) (Table 6.4). Subjects that at least half of the students reported that they might be offended by are all social identities: people with disabilities (63.7%), Muslims (62.4%), women (61.6%), African Americans (60.9%), Mexicans (60.6%), transgender people (59.9%), gay or lesbian people (58.8%), Jewish people (57.1%), and Christians (51.1%) **(**Table 6.4**)**. There were three subjects that appeared to be perceived of as universally funny, yet inoffensive because at least three quarters of students reported that they might find the subject funny and less than 2% of students reported that they might find the subject offensive: science (89.3% find funny, 1.5% find offensive), college (84.7% find funny, 1.5% find offensive), and television (75.9% find funny, 1.3% find offensive) **(**Table 6.4**)**.

We found that, in general, males were more likely to report that they find jokes about the subjects funny, while females were more likely to report that they find jokes about the subjects offensive. There were 23 subjects that males were more likely than females to report that they might find funny, including all 13 subjects related to social identities. However, there was only one subject, food puns, that females were more likely than males to report that they might find funny (Table 6.5). Conversely, there were 25 subjects that females were more likely than males to report that they might find

offensive, including all 13 subjects related to social identities and both subjects related to relationships. Males were never more likely than females to report that they might find a subject offensive (Table 6.6).

Table 6.5

Gender Differences in What Subjects Students Report They Might Find Funny if an Instructor of a College Science Course Were to Tell a Joke About Them

Potentially humorous subjects	% of females who might find jokes about subject funny if told by a science instructor (n = 1004)	% of males who might find jokes about subject funny if told by a science instructor (n = 606)	Gender of students significantly more likely to find subject funny	p-value[a]	Standardized effect size- odds ratio that males will perceive the subject funny
Science	89.1%	89.6%		0.772	
College	85.5%	83.3%		0.252	
Television	78.7%	71.9%		0.002	
Food puns	71.9%	59.6%	Females	<0.001	1.7x less likely
Relationships	60.7%	65.3%		0.060	
Cute animals	58.6%	51.5%		0.006	
Dogs	58.6%	50.3%		0.001	
Cats	55.2%	49.7%		0.032	
Sports	45.6%	62.0%	Males	<0.001	2.0x more likely
Students	49.2%	54.8%		0.030	
Politics	40.5%	62.0%	Males	<0.001	2.4x more likely
Donald Trump	43.1%	50.7%		0.003	
Sex	39.2%	51.5%	Males	<0.001	1.6x more likely
Farts or poop	31.6%	36.0%		0.070	
Hillary Clinton	19.8%	39.9%	Males	<0.001	2.7x more likely
Old people	21.1%	37.3%	Males	<0.001	2.2x more likely
Genitalia	16.5%	34.3%	Males	<0.001	2.6x more likely
Republicans	16.7%	33.3%	Males	<0.001	2.5x more likely
Divorce	16.0%	30.2%	Males	<0.001	2.3x more likely
Sean Spicer	14.5%	30.7%	Males	<0.001	2.6x more likely
Democrats	12.6%	33.3%	Males	<0.001	3.5x more likely
Women	8.1%	29.4%	Males	<0.001	4.8x more likely
Weight	7.8%	28.5%	Males	<0.001	4.8x more likely
Mormons	9.3%	25.2%	Males	<0.001	3.3x more likely
Christians	8.5%	25.2%	Males	<0.001	3.7x more likely
Catholics	6.7%	22.8%	Males	<0.001	4.1x more likely
Mexicans	5.8%	22.3%	Males	<0.001	4.7x more likely

Immigration/Immigrants	4.9%	23.3%	Males	<0.001	5.9x more likely
Jewish people	4.6%	21.8%	Males	<0.001	5.8x more likely
African Americans	4.5%	20.6%	Males	<0.001	5.5x more likely
Gay or lesbian people	4.0%	20.6%	Males	<0.001	6.2x more likely
Muslims	3.5%	20.5%	Males	<0.001	7.1x more likely
Transgender people	3.6%	19.8%	Males	<0.001	6.6x more likely
People with disabilities	2.7%	16.8%	Males	<0.001	7.3x more likely

Note. The odds ratio that males compared to females might perceive the subject funny are reported for subjects where the gender difference is significant. [a]A Bonferroni-adjusted alpha level of <0.001 was used.

Table 6.6

Gender Differences in What Subjects Students Report They Might Find Offensive if an Instructor of a College Science Course Were to tell a Joke About Them

Potentially humorous subjects	% of females who might find jokes about subject offensive if told by a science instructor (n = 1004)	% of males who might find jokes about subject offensive if told by a science instructor (n = 606)	Gender of students significantly more likely to find subject offensive	p-value[a]	Standardized effect size- odds ratio that <u>females</u> will perceive the subject offensive
Science	1.2%	1.8%	-	0.31	
College	1.6%	1.5%	-	0.87	
Television	1.1%	1.8%	-	0.23	
Food puns	1.0%	2.3%	-	0.04	
Relationships	10.8%	5.8%	Females	<0.001	2.0x more likely
Cute animals	4.0%	3.1%	-	0.38	
Dogs	5.2%	3.5%	-	0.11	
Cats	4.0%	2.6%	-	0.12	
Sports	5.0%	2.5%	-	0.02	
Students	20.0%	10.6%	Females	<0.001	2.1x more likely
Politics	20.9%	8.7%	Females	<0.001	2.8x more likely
Donald Trump	21.3%	10.9%	Females	<0.001	2.2x more likely
Sex	24.4%	10.2%	Females	<0.001	2.8x more likely
Farts or poop	13.1%	8.9%	-	0.01	
Hillary Clinton	30.8%	11.4%	Females	<0.001	3.5x more likely

Old people	36.9%	18.0%	Females	<0.001	2.7x more likely
Genitalia	43.5%	18.2%	Females	<0.001	3.5x more likely
Republicans	44.1%	21.1%	Females	<0.001	2.9x more likely
Divorce	34.2%	18.8%	Females	<0.001	2.2x more likely
Sean Spicer	17.1%	8.9%	Females	<0.001	2.1x more likely
Democrats	50.7%	22.3%	Females	<0.001	3.6x more likely
Women	76.8%	37.3%	Females	<0.001	5.5x more likely
Weight	61.8%	26.4%	Females	<0.001	4.5x more likely
Mormons	55.5%	29.2%	Females	<0.001	3.0x more likely
Christians	61.3%	36.0%	Females	<0.001	2.8x more likely
Catholics	61.3%	31.4%	Females	<0.001	3.5x more likely
Mexicans	71.6%	43.4%	Females	<0.001	3.3x more likely
Immigration/Immigrants	61.6%	30.0%	Females	<0.001	3.7x more likely
Jewish people	68.1%	39.6%	Females	<0.001	3.3x more likely
African Americans	73.2%	41.6%	Females	<0.001	3.8x more likely
Gay or lesbian people	71.5%	38.4%	Females	<0.001	4.0x more likely
Muslims	73.7%	44.7%	Females	<0.001	3.5x more likely
Transgender people	73.2%	38.4%	Females	<0.001	4.4x more likely
People with disabilities	77.6%	41.4%	Females	<0.001	4.9x more likely

Note. The odds ratio that females compared to males might perceive the subject offensive are reported for subjects where the gender difference is significant. A Bonferroni-adjusted alpha level of <0.001 was used.

Study III Conclusion. In college science classrooms, students are most likely to find instructor jokes funny if they are about college, science, or television and students are most likely to be offended by instructor jokes about social identities, particularly social identities that are historically or currently marginalized in the United States. There are gender differences in whether students might find jokes about specific subjects funny and offensive. Males are more likely to find jokes about social identities funny, while females are more likely to find joke about social identities offensive.

DISCUSSION

Despite the potential for humor to positively influence students in science courses, there has been little research on student perception of science instructor use of humor in

the college science classroom. In this manuscript, we document student perceptions of instructor use of humor in college science classrooms, which give insights into how science instructors can use humor to maximize student experiences, while minimizing the potentially negative effects of humor.

Overwhelmingly, students reported that they appreciated when instructors used humor. However, this was the first study to explore why instructor use of humor may be particularly appreciated in college science courses. Students acknowledged that science courses can be stressful and that science content is especially difficult, but that humor helps lighten the mood of science classes, decreases stress levels, and improves their perceived ability to remember science. Future studies could explore the extent to which humor benefits students in science courses compared to courses with more positive reputations such humanities classes (Strenta et al., 1994).

For the majority of students in this study, when science instructors used humor that students did not think was funny, it did not have an effect on their attention to course content, how relatable they perceived the instructor to be, or their sense of belonging to the class. Thus, if an instructor tells a joke that falls flat, it is likely not harming students. However, this is not the case if students find an instructor's use of humor to be offensive. We found that if students perceive a science instructor's use of humor as offensive, it can negatively influence how relatable students perceive the instructor. Previous research also suggests that negative and hostile humor can harm student-instructor relationships, particularly if students previously perceived the instructor to be immediate, or physically and psychologically close with students, because the negative humor contradicts their warm and open style (Gorham & Christophel, 1990). Further, we found that instructors'

use of offensive humor tends to decrease student sense of belonging to the course, which has been shown to be an important predictor of student retention (Good, Rattan, & Dweck, 2012; London, Rosenthal, Levy, & Lobel, 2011). Over 40% of students reported that offensive humor can also decrease their attention to course content. Offensive humor may negatively affect student attention because it increases student cognitive load, or the amount of information that a student can hold in their working memory. This may be particularly true if the joke is offensive because it targeted an identity group that they belong to (Barnes, Truong, & Brownell, 2017; Katelyn M. Cooper & Brownell, 2016c; Steele & Aronson, 1995).

Notably, if a college science instructor is able to tell a joke that males and females think is funny, our findings suggest that both genders benefit equally. Similarly, if a college science instructor tells a joke that males and females both perceive as offensive, there is little evidence to suggest that females would be more harmed than male students. Therefore, based on our findings, females are more likely to be negatively affected by humor because they find more subjects offensive, not because of their response to the offensive humor.

Our study identified three subjects- science, college, and television- that the vast majority (> 75%) of students found funny, and that a small minority (<2%) of students found offensive. Neither males nor females were more likely to find these subjects funny or offensive. Thus, we conclude that instructors may want to consider these subjects when integrating humor into the college science classroom. Incorporating jokes about science into the classroom may be particularly beneficial to instructors because prior literature suggests that jokes about course content may be received positively by students,

even when delivered by instructors who students consider less immediate, or more psychologically distant (Frymier, Wanzer, & Wojtaszczyk, 2008). Further, jokes about science may be helpful to include in class if an instructor is using humor to promote student learning gains. Researchers have started to investigate whether the subject of humor matters for student learning and have found that humor illustrating course concepts can improve student learning in the course compared to humor that is unrelated to course content (Hackathorn, Garczynski, Blankmeyer, Tennial, & Solomon, 2011; Kaplan & Pascoe, 1977; Ziv, 1988). However, there are different ways to tell a joke about science, including ways to make it offensive, so instructors will want to be thoughtful in how they deliver jokes about science.

It is important to note that the subject of a joke is not enough to definitively determine whether the joke will be perceived as funny. Who is telling the joke, how the joke is delivered, other subjects within the joke, and the audience member's culture and sense of humor all influence how the joke will be received (S Alatalo & Poutiainen, 2016; Teslow, 1995; Torok et al., 2004). Future research should explore the relative influence of these parameters in efforts to identify ways to maximize the benefits of instructor use of humor and minimize the negative consequences. Finally, we only explored differences between men and women in their perceptions of instructor use of humor, but future work could extend to exploring how other social identities differentially perceive instructor humor and the relative impact on students in science.

LIMITATIONS

This research was conducted across multiple classes at one institution in the Southwestern United States. Humor can be highly dependent on culture and thus, these

findings may not be applicable to non-Western cultures (Banas et al., 2011; Teslow, 1995). This research was dependent on student self-report of their perceptions of instructor humor and how that humor may impact them, which could be influenced by the extent to which a student has previously experienced instructor humor. We asked student what subjects they might find funny and offensive if a science instructor were to tell a joke about them. There was no way to control for what type of instructor the student imagined would be telling the joke or the possible context of the jokes that students might have thought about. Further, although we sampled from multiple science courses, biology majors were overrepresented in our sample, which could have biased our results. However, we know of no literature suggesting that students from different science majors would interpret humor differently and students were asked to think broadly about their science courses, which for a typical biology major would include biology, physics, and chemistry courses. Thus, generalizations from this study should be made with caution and these findings would benefit from being replicated at different types of institutions across the US.

CONCLUSIONS

The majority of students appreciate when instructors use humor in college science classrooms. While funny instructor humor tended to positively affect student attention to course content, instructor relatability, and student sense of belonging to the course, for most students, unfunny humor did not seem to affect these constructs. Students reported that offensive instructor humor tended to decrease their sense of belonging to the course and instructor relatability. There were few significant gender differences in how funny instructor humor and offensive instructor humor affected students, but numerous

significant gender differences in the topics that students found funny and offensive. Lastly, students are most likely to find a joke funny and least likely to find a joke offensive if the joke is about science, television, or college and students are most likely to find instructor jokes offensive if they are about social identities.

CHAPTER 7

CONCLUSION

My work suggests that students' experience with other students and faculty can positively, neutrally, or negatively affect their social integration in college. Specifically, Chapter 2 suggests that students' hidden identities, such as the LGBTQIA identity, are more relevant in active learning classes where we are asking students to work together. The increased relevance of one's identity can have a positive impact on students; for example, active learning allowed LGBTQIA students to identify and connect with fellow members of the community, making them feel more included in the larger scientific community. However, it can also have a negative impact on students' social integration; derogatory comments about the LGBTQIA identity from other students and the heteronormative science environment can make students feel less welcome in their college science courses. Chapter 3 suggests that students' identities can subconsciously influence their social experiences, which in turn can affect their social and academic integration. Male students reported higher academic self-concept than female students; that is, they perceived that they are smarter with regard to the class as a whole and with regard to their groupmate. Students' academic self-concept influenced their participation in class; students with higher academic self-concept were more likely to report speaking out in small group discussion. These findings suggest that students' social identities can influence their academic integration, which in turn can influence the extent to which they participate in social situations in active learning biology classes. In Chapter 4, I found that the way instructors implement active learning, specifically social situations in active learning, such as groupwork, can cause students to feel more or less socially integrated

into the classroom. By making strategic choices, such as allowing students to choose whom they work with in class, instructors can positively impact students' social integration in the college science classroom. In Chapter 5, I propose name tents as a tool to increase students' social integration. Students report that name tents not only positively influence their social experiences with the instructor, but also allow them to build positive social relationships with other students. Finally, in Chapter 6, I highlight how instructor behavior can positively, neutrally, and negatively affect student social integration. That is, instructor use of humor can impact students differently depending on their social identities, specifically their gender, and depending on the subject that instructors choose to joke about. In conclusion, my research suggests that while active learning increases the number of social interactions among students and between students and instructors in class, it provides opportunities that can lead to positive social integration, but that these opportunities do not always lead to positive social integration and can even lead to negative social integration. I identified factors such as students' identities, students' perceptions of their intelligence, and the way active learning is implemented that can affect the relationship between active learning and students' social integration. However, a specific finding that warrants additional exploration is student fear of negative evaluation. Fear of negative evaluation emerged from student interviews in the studies described in Chapters 2, 4, and 5 (Table 7.1) and future directions would be to explore how this construct influences students' social integration in active learning classes.

Table 7.1

Examples of Fear of Negative Evaluation Influencing Students' Social Integration in Active Learning Classes

Thesis chapter	Example quote describing fear of negative evaluation
Chapter 2: Coming out in class: Challenges and benefits of active learning in a biology classroom for LGBTQIA students	"In discussion-based courses, I think it's rougher for my emotional state when I feel like I need to talk to people, but I feel uncomfortable doing that, because I don't know what their perception of me is. I worry 'Do they like me? Do they think that I'm stupid? (…) It's just so much pressure talking to people and I think it takes away from what I get from a course if I'm focused on people's perception of me versus what I'm actually supposed to be focusing on in the class."
Chapter 4: The influence of active learning practices on student anxiety in college science classrooms	"Sometimes when we're discussing clicker questions, [the instructor] walks up and tries to engage with the students. It makes me nervous because I don't know [the answer]. I'm really intimidated by professors because I guess it's really important to me what they think of me."
Chapter 5: What's in a name? The importance of students perceiving an instructor knows their name in a high enrollment biology classroom	"[An instructor knowing my names is] important because you can become comfortable, which eventually leads to asking more questions without fear of embarrassment or judgement."

WHAT IS FEAR OF NEGATIVE EVALUATION?

Fear of negative evaluation (FNE) refers to the sense of dread associated with being unfavorably evaluated while anticipating or participating in a social situation (Weeks et al., 2005). Fear of negative evaluation is distinct from the broader term "test anxiety," which refers to an individual's fear of being evaluated in any situation, including situations that are not social (Cassady & Johnson, 2002). Although test anxiety is commonly misused to exclusively reference anxiety about tests or exams, test anxiety is meant to describe an individual's fear of any evaluative situation, either social or non-social. In contrast, FNE refers specifically to one's fear of negative evaluation in a social situation. Individuals who experience FNE are particularly concerned about how others

will evaluate them, thus there must be someone else present who could evaluate them. Individuals with FNE distress over negative evaluation and judgement by others, and expect that others would evaluate them negatively (Watson & Friend, 1969). While varying levels of FNE can influence how individuals experience social interactions, intense FNE has been identified as a defining characteristic of social anxiety (Watson & Friend, 1969), one of the most prevalent mental health conditions among college students (Center for Collegiate Mental Health, 2015).

There is emerging evidence that active learning activities can exacerbate anxiety in college science students (England et al., 2017; Cooper, Downing et al., under review). One study explored the presence of undergraduates' anxiety in biology active learning classes and found that social anxiety and communication apprehension, or the fear associated with real or anticipated communication with others (McCroskey, 1978), are present when students engage in active learning practices such as cold call and group work (England et al., 2017). Work conducted as part of my thesis, including 52 in-depth interviews with students enrolled in active learning science courses, identified that fear of negative evaluation may be an underlying mechanism of students' social anxiety and communication apprehension in active learning (Cooper, Downing et al., under review).

For over 40 years, researchers have recognized that some students are reluctant to participate in discussion and fear participating in class (summarized in Rocca, 2010). Early literature primarily acknowledged students' fears about participating in courses where developing student communication skills was a course goal, such as in business or communication courses (Rocca, 2010). However, since the push to transition many types of courses from traditional lecture to active learning, there has been an increase in

research focused on student communication apprehension, or students' fear of engaging in classroom activities that require them to communicate with others (Rocca, 2010). Despite the increasing recognition of communication apprehension, few studies have probed underlying causal factors, such as students' fear of negative evaluation. However, there have been some studies exploring FNE in the context of language learning courses. In these language learning courses, college students are asked to regularly participate in exercises where they speak with other students, speak with the instructor, and speak out in front of the class. Studies have shown that FNE can cause undergraduates to have anxiety when they communicate with other students in language learning courses (Aydin, 2008) and may negatively influence students' learning experiences (Horwitz 1986; Aida, 1994). For example, in a survey of 135 college students enrolled in Spanish classes, students described that FNE causes them to be reluctant to participate in front of the whole class (Young, 1990). Additionally, in an interview study at the Universidad de Atacama in Chile, students enrolled in a second-year English language course perceived that FNE caused them to make mistakes when speaking in class (Gregersen & Horwitz, 2002). These studies highlight that FNE may negatively influence students' social integration in college courses where there are numerous social evaluative situations. However, I am unaware of any studies that have explored FNE in the context of active learning science courses.

ACTIVE LEARNING COURSES INCREASE THE NUMBER OF SOCIAL EVALUATIVE SITUATIONS

College biology classes have increasingly transitioned to active learning spaces (AAAS, 2015). A meta-analysis of 225 studies showed that active learning enhances

student exam performance, raises average letter grades, and decreases student failure rate by half (Freeman et al., 2014). Active learning is a broad term that describes any classroom practice that is not passive lecturing; students in active learning are engaged in their own learning (Freeman et al., 2014). Although active learning courses can be structured in ways that allow for students to work alone, a common component of active learning is frequent interactions among students and between students and the instructor (Freeman et al., 2014; Eddy et al., 2015). For example, a student in an active learning class may be asked to answer an instructor-generated question in front of the whole class, talk with an instructor about a question one-on-one during class, work with other students to complete a worksheet, or talk to their neighbor when answering a clicker question. In each of these situations, the student has an audience and thus, there is a possibility of being evaluated. Therefore, all of these situations would be considered social evaluative active learning activities because any situation in which a student perceives they have an audience is a social evaluative situation (Heimberg et al., 2010). While traditional lecture courses may have a small number of social evaluative situations, such as students asking questions in front of the whole class, active learning courses greatly increase the number of social evaluative situations among students. Further, students in traditional lecture courses often get to choose whether they want to put themselves in a social evaluative situation. For example, a student can choose whether they want to ask the instructor a question in front of the class, or answer an instructor-posed question. However, active learning classes often require all students to participate in group work or the instructor may implement random call or cold call where any student could be asked to answer a question, not just a student who wants to volunteer.

While there is evidence to suggest that, on average, answering instructor-generated questions in front of the whole class and talking with others about biology questions enhance student learning (Buck 1996; Smith et al., 2009; Eddy et al., 2015;), an implicit assumption is that students are equally engaging in and learning from such activities. While many college biology students agree that increased interactions with each other and the instructor enhance their learning experience (Cooper et al., 2017a, 2017b), recent findings suggest that some students, particularly women and individuals from underrepresented racial minority groups, may not be fully benefiting from these interactions and for some, these interactions can be detrimental to their learning experience.

INEQUITIES IN COMFORT AND PARTICIPATION IN SOCIAL EVALUATIVE OPPORTUNITIES

Recent studies suggest that, when given a choice, college biology students do not participate equally in social evaluative active learning activities (Eddy, Brownell et al., 2014) and that when students are forced to participate, there are inequities in comfort among students of different identities (Eddy, Brownell et al. 2015). In a study exploring whose single voices are heard during whole class discussion, Eddy, Brownell, and Wenderoth found that, although females make up 60% of college biology classrooms, their voices are only heard 40% of the time (Eddy, Brownell et al., 2014). They followed up this study by showing that women were less comfortable participating in whole class discussion than men were, but were equally comfortable participating in small groups (Eddy, Brownell et al. 2015). However, in those small group discussions, women were less likely to prefer to be a leader compared to men. Additionally, Asian Americans and

Underserved Americans, including Latino/a, Black, Hawaiian and Pacific Islander, and Native American students, were more likely to prefer listening roles compared to white students (Eddy, Brownell et al., 2015). Such findings suggest that males and white students, who appear to be more comfortable taking on talking roles in group work, may be contributing to group discussions more than their female and URM counterparts.

Fear of negative evaluation may explain why some individuals avoid participating in whole class discussion or prefer more passive roles during group work. The FNE literature suggests that individuals with FNE avoid situations where there is the potential for them to be evaluated by others (Watson & Friend, 1969) and in one of the only studies to explore how FNE influences students, students reported that FNE caused them to avoid participating in class (Young 1990). Thus, FNE may partially explain participation inequities in active learning classrooms.

WHY PARTICIPATION INEQUITIES MATTER

Inequities in participation are concerning because studies suggest that students who do more of the talking in small group work learn more. For example, Beichner and colleagues (2007) found that it was the top third of the class that benefited the most from peer discussions, the same third of the class that they proposed did most of the explaining in these groups. One theoretical framework that could explain these observations is Chi's active-constructive-interactive conceptual framework for differentiating learning activities by the type of discussions that students engage in during class (Chi, 2009). This hierarchical framework proposes that interactive activities are better than constructive activities, which are better than active activities, which are better than passive activities. When instructors ask students in engage in peer interaction, there is

often the implicit assumption that students will engage in exchanges of logic and knowledge and, thus, build on each other's statements, which according to Chi, is an interactive activity. However, it is also possible that the peer interaction will only be constructive, with one student either self-explaining the problem to him/herself or one student explaining the problem to another student, but with no co-creation of knowledge between the students in the group. While self-explaining or talking out loud could be a useful constructive activity, this framework asserts that it is not as useful as jointly explaining with a partner, which is an interactive activity.

Several studies have substantiated this framework and have found that students who engage in interactive discussions experience greater learning gains (Hausmann & VanLehn 2007; Chi et al. 2008), but these studies focus on the benefit and costs of interactions for the student doing the explaining. In a study of college biology students in active learning classrooms, Wiggins and colleagues found that students experience higher learning gains when they engage in interactive activities, which required students to work with others in order to complete an activity, compared with constructive activities, which did not require students to work with others to complete an activity (Wiggins et al., 2017). However, in peer groups, there are students who may experience a cost if one student does most of the explaining: the students in the group who only listen. These students are not being any more active than they would be in a passive lecture class and thus do not receive the benefit of constructing a response. Thus, a student who does not participate in the group may be experiencing passive group work, which may lead to less learning than if a student is constructing their own knowledge and getting feedback on that knowledge.

It is possible that students with FNE are having a different experience during group work than students without FNE, especially if students with FNE prefer to play a passive role in conversation and are not engaging in interactive conversations with other students or the instructor because of their FNE.

WHY FORCING STUDENTS TO PARTICIPATE MAY NOT ALLEVIATE INEQUITIES IN SOCIAL EVALUATIVE SITUATIONS

Requiring all students to participate or requiring students to participate in social evaluative situations at random have been proposed as solutions to close participation gaps and enhance undergraduate learning gains. For example, Eddy, Brownell and colleagues suggested that instructors could use random call, or use a randomly generated list of student names to call on students during class, instead of calling on students who volunteer, as a way to close the gender gap in who answers instructor questions (2014). Further, structuring an in-class activity so that each individual in a small group is allotted a specific and equal period of time to speak has been proposed as a way to promote equity in active learning classes (Tanner, 2013).

While these methods close gaps in *who* is participating, they do not guarantee that students have the same experiences when participating or that students benefit to the same extent from participating in social evaluative active learning situations. Our work exploring undergraduate anxiety in active learning biology classrooms suggests that students who have historically chosen not to participate in social evaluative active learning situations may have made that decision because they were unable to think through the proposed question and/or feared that they would be unable to articulate their knowledge about biology, which may be due to FNE (Cooper, Downing et al., under

review). Individuals who experience FNE constantly monitor their surroundings for threat of social evaluation and if they are forced into a social evaluative situation, they monitor their performance for behavior that might elicit negative evaluation from others (e.g. blushing, stuttering, or misspeaking). Thus, individuals who experience FNE are predicted to have more trouble completing cognitively challenging tasks, such as thinking through a biology question or talking about biology, because of the increased cognitive capacity that they devote to screening for and monitoring social evaluative situations (Heimberg et al., 2010).

If, while anticipating or participating in social evaluative active learning situations, students with FNE have trouble thinking through content related questions and articulating what they know about biology, they may not be benefiting from participating social evaluative active learning situations to the same extent as their peers who do not experience FNE. Further, their contributions to group discussion or to whole class discussion may even confuse other students who are listening to their explanation if they have such trouble articulating their responses. Additionally, if students with high FNE are forced to participate and have a negative experience (e.g. an instructor blatantly tells a student in front of the class that their answer is wrong), then their FNE is likely going to be exacerbated, further hindering their future performances (Heimberg et al., 2010; Cooper, Downing et al., under review).

Thus, structuring equitable student participation may be closing the participation gap in whose voices are heard, but it may not be closing the participation gap with regard to who is able to participate by thinking through the biology problem, who is able to clearly articulate their thoughts, and who is benefiting from participating in social

evaluative active learning situations. In fact, requiring students to participate may be exacerbating these gaps. A possible solution that would complement requiring students to participate may be to identify ways to decrease students' FNE in active learning classrooms.

PRELIMINARY DATA FROM MY THESIS THAT PROVIDES SUPPORT FOR STUDENT FEAR OF NEGATIVE EVALUATION IN ACTIVE LEARNING

In Chapter 4, the study exploring student perceptions of elements of science active learning classrooms that affect students' levels of anxiety, I conducted in-depth, semi-structured, hour-long interviews with a sample of 52 students enrolled in introductory and upper-level active learning biology classes. From these interviews, I identified FNE as one of the underlying causes of student anxiety in active learning classrooms. Specifically, I found that social evaluative active learning situations such as interacting one-on-one with the instructor, talking with other students during group work, and instructors using random call during class exacerbated many students' anxiety. When I probed into why these experiences cause students to feel anxious, 57.7**%** of students described core elements of FNE without being specifically prompted to talk about FNE (Table 7.2). This means that this percentage may underestimate how prevalent FNE is for these students.

Table 7.2

Students Describe Fear of Negative Evaluation with Regard to 1) One-on-One Interactions With the Instructor During Class, 2) Interactions With Other Students During Group Work, and 3) Instructors Practicing Random Call.

	Student example quote	**Student example quote**

1. FNE Student/instructor interactions in class	"Sometimes when we're discussing clicker questions, [the instructor] walks up and tries to engage with the students. It makes me nervous because I don't know [the answer]. I'm really intimidated by professors because I guess it's really important to me what they think of me."	"[When an instructor] is approaching during discussion time and says, "What do you guys think?" (...) I don't want to look bad in front of them, and have them be like, "OK, she doesn't know what she's talking about." Every time [the instructor] walks around I'm like, "Please don't stop on me." I hope they just keep going to other people, or address my partner and not me."
2. FNE Student/student interactions during group work	"I've spent up to a week thinking about [what I've said to my groupmate] (…) I embarrass myself, then I think about it the next time I see them, I'm like, 'What if they bring up last time, that I didn't know the answer? Or what if they make a joke?' Some of the people like to make jokes about, "Oh, remember last time?" And then I just want to avoid the situation."	"[My anxiety during group work] goes back to the central theme of being judged. Some things I'll say will keep me awake at night. It's like, 'Oh did I overshare? Did I not talk enough?'"
3. FNE random call	" If [the instructor] picked on me, I would not want to embarrass myself in front of 300 students that are in that class, because then I would feel like I'm stupid and people would think of me as a stupid person."	"Having to speak in front of a large group of people makes me anxious. It's the fear of being wrong or sounding dumb- being embarrassed."

FNE INFLUENCES STUDENTS IN ACTIVE LEARNING BIOLOGY CLASSROOMS

In this interview study, students who expressed FNE described that the mere threat – not necessarily the experience - of a social evaluative situation hindered their ability to think through a science problem. This is consistent with literature that suggests that individuals with FNE focus a significant amount of their attention on monitoring their environment for a possible threat of evaluation and therefore, have less cognitive capacity to engage in other activities, such as thinking through a problem in class (Heimberg et al., 2010). Further, students in these interviews who expressed FNE explained that if they're forced to participate in a social evaluative situation, they were

often unable to articulate what they know about science. This is also supported by literature which suggests that individuals with FNE are monitoring their own performance for behaviors that they perceive will elicit negative evaluation from others such as sweating, stuttering, or saying the wrong answer. Because these students are engaging in multiple tasks (e.g. monitoring the evaluative situation and contributing to discussion), they are more likely to struggle with challenging cognitive tasks, such as explaining a difficult concept in biology (MacLeod and Matthews, 1991; Heimberg et al., 2010). Of the 30 students who I interviewed who described experiencing fear of negative evaluation, 33% described that they struggled with thinking through a science problem when anticipating a social evaluative active learning situation and 40% described that they were unable to articulate their knowledge about biology during social evaluative active learning situations. See Table 7.3 for example quotes from students whom I interviewed describing these phenomena.

Table 7.3

Students Describe How Anticipation of and Participation in Social Evaluative Active Learning Situations Hinder Their Ability to Think Through Questions As Well As Their Ability To Articulate Their Knowledge About Science

	Example student quote about student/instructor interaction during class	**Example student quote about student/student interaction during group work**	**Example student quote about random call**
Threat of social evaluative active learning situation inhibits students' ability to think	"[When the instructor is coming up to me] my mind goes blank. Even if I had a really complete thought before, it's just gone."	"[When I am anticipating group work] my heart starts beating really quickly. I can get really sweaty. My face gets really flushed. Mentally, I can't really focus. I get really flustered really	"[When the instructor is practicing random call] your brain just shuts off and you're looking for an answer but then you can feel that there's pressure there so you're not actually thinking of

about science		quickly and I can't keep my thoughts on track."	a good answer. There's panic in the moment and then after. Even though people have moved on, you're still kind of reeling from it."
Participating in a social evaluative active learning activity inhibits students' ability to articulate their knowledge about science	"I freeze up and I can't really say they answer but I kind of have to have something come out in order for the teacher to be happy. It usually is something that is related to the subject but it's worded really weirdly. I'll spit something out and the teacher is like, 'I don't understand.'"	" I have the thought in my head, but it doesn't come out necessarily the way I want it to. It's hard to explain myself."	"Being random called, that level of anxiety, it just throws me. I knew the answer in my head, but just being in that moment, I just wasn't able to put those thoughts into a clear, coherent sentence. It just made me feel bad. I felt sick to my stomach. It doesn't really help you because then you're just inhibited."

WHO IS MOST LIKELY TO EXPERIENCE FNE?

Few studies have explored the prevalence of FNE and I know of no studies that have explored the prevalence of FNE in college classes. Watson & Friend (1969) developed a scale to measure FNE and found that women reported more FNE than men, although this result only approached significance. In our interview study exploring the experiences of student anxiety in active learning classes, I found that 60.0% of female participants and 45.5**%** of male participants described experiencing FNE in their undergraduate active learning science courses. This difference is not significant (p =0.3), however just because a student did not bring up FNE in their interview does not mean that they do not experience FNE. Unfortunately, no studies have explored differences among individuals of other social groups including individuals of different races/ethnicities, academic abilities, or native languages. However, it is hypothesized that there is a relationship between stereotype threat, or fear of confirming stereotypes

about a social group to which one belongs and FNE. In a survey study of 94 socially anxious individuals, Johnson and Anderson (2009) found that stereotype confirmation concerns predicted fear of negative evaluation in both Caucasian and African American individuals. I predict that FNE may be more apparent in students with underrepresented racial minority (URM) identities because URM students may be more likely than white students to experience stereotype confirmation concerns in undergraduate biology classrooms (Steel & Aronson, 1995). It is important to note that FNE is not necessarily a binary condition, thus it may be inaccurate to say that some people have FNE and some do not. It is likely that, similar to anxiety, everyone experiences FNE to some extent, but for some individuals high FNE influences their daily experiences. I predict that individuals with the highest levels of FNE will also be most likely to describe difficulty in social evaluative active learning situations.

Given my data, which suggest that FNE negatively influences students' experiences in active learning classrooms, primarily by hindering their ability to think through content problems and articulate their thoughts about biology, lessening FNE may improve students' experiences in active learning courses and positively influence the potential benefits that a student with FNE could gain from participating in social evaluative active learning activities.

FUTURE DIRECTIONS: IDENTIFY HOW FEAR OF NEGATIVE EVALUATION INFLUENCES STUDENTS IN LARGE-ENROLLMENT ACTIVE LEARNING BIOLOGY CLASSROOMS

Future directions would be to identify student fear of negative evaluation in the context of large-enrollment active learning classrooms and determine whether FNE

disproportionately affects students with different social identities, because this may help to explain some of the participation and comfort gaps reported in active learning biology courses. Specifically, developing and validating scales with a national sample of college biology students to measure FNE, students' ability to articulate their knowledge during class and students' ability to think through biology problems would allow for modeling the relationship between FNE and these student outcomes.

FINAL THOUGHTS

National recommendations have positioned for college biology courses to be transformed from traditional lecture to active learning and as a result, an increasing number of biology classrooms have transitioned to active learning spaces (AAAS 2011; AAAS, 2015; PCAST, 2012). The term active learning is often used as an umbrella term to include everything that is not passive lecture; in active learning, students engage in the process of learning through student-centered activities (Freeman et al., 2014). Although active learning classrooms can be structured so that students can work by themselves, often students have more opportunities to interact with their peers and the instructor during active learning (Eddy et al., 2015; Freeman et al., 2014). Such opportunities can be considered social evaluative situations, which are defined as situations where a student is asked to talk in front of someone who has the potential to evaluate them (Watson & Friend, 1969). Depending on the specific active learning activity, this person who is evaluating the student could be a peer, a group of peers, the whole class, learning/teaching assistants, and/or the instructor. Many students perceive that increased opportunities to discuss their ideas about biology with their peers or with the instructor enhances their learning experience (Cooper et al., 2017a; Cooper et al., 2017b; Cooper,

Downing et al., in prep). However, for students with fear of negative evaluation, engaging in an increased number of social evaluative activities during class could negatively affect their learning experience (Cooper, Downing et al., in prep). Fear of negative evaluation (FNE) refers to the sense of dread associated with being unfavorably evaluated while participating in a social situation or even anticipating the possibility of participating in a social situation (Watson & Friend, 1969; Weeks et al., 2005). Notably, this means that a student could be negatively affected even if the active learning social evaluative activity does not occur, because just the thought of it could elicit these feelings of fear and dread. People who experience FNE are usually apprehensive about others' evaluations of them, distress over negative evaluations by others, and expect that others will evaluate them negatively (Watson & Friend, 1969). Fear of negative evaluation may explain why a subset of students report that they do not learn as well and are more uncomfortable in active learning classrooms compared to traditional lecture (Cooper and Brownell, 2016; Cooper et al., 2017a; Cooper, Downing et al., in prep) and why some students are particularly resistant to participating in active learning activities (Cooper & Brownell, 2016; Cooper et al., 2017a.; Cooper et al., 2017b; Seidel and Tanner 2014).

Fear of negative evaluation remains relatively unexplored among college students in the context of education, presumably because there have historically been few social evaluative situations in traditional lecture college courses. To my knowledge, FNE has never been explored in the context of undergraduate active learning courses, yet it may be negatively influencing students' experiences in active learning. I propose that FNE may be contributing to established inequities in participation and comfort in the classroom

(Eddy, Brownell et al., 2014; Eddy, Brownell et al., 2015) and lessening student FNE may diminish some of these gaps.

My thesis work indicates that some students experience fear of negative evaluation while anticipating or participating in active learning activities that ask students to engage with each other, engage with the instructor, or to speak in front of the whole class. Although interview studies can help us develop hypotheses, they are not helpful in establishing more generalizable patterns. Developing tools to measure student fear of negative evaluation in large-enrollment active learning classrooms is an important next step. Understanding how fear of negative evaluation influences students when they are anticipating or participating in social evaluative active learning situations could draw attention towards an unexplored underlying factor that may be important to address when creating more inclusive active learning classrooms.

REFERENCES

Adedokun, O. A., Bessenbacher, A. B., Parker, L. C., Kirkham, L. L., & Burgess, W. D. (2013). Research skills and STEM undergraduate research students' aspirations for research careers: Mediating effects of research self-efficacy. *Journal of Research in Science Teaching*, *50*(8), 940–951. https://doi.org/10.1002/tea.21102

Agresti, A., & Franklin, C. A. (2012). *Statistics: The Art and Science of Learning From Data, Books a la Carte Edition (3rd Edition* (3rd ed.). Pearson.

American Association for the Adcancment of Science. (2011). Vision and Change in Undergraduate Biology Education: A Call to Action. Washington, DC: CBE-LIfe Science Education. Retrieved from http://visionandchange.org/files/2013/11/aaas-VISchange-web1113.pdf

American College Health Association. (2017). *American College Health Association National College Health Assessment Spring 2017 Reference Group Executive Summary* (p. 19). Hanover, MD. Retrieved from http://www.acha-ncha.org/docs/NCHA-II_SPRING_2017_REFERENCE_GROUP_EXECUTIVE_SUMMARY.pdf

American Physical Society. (2016). LGBT Climate in Physics: Building and Inclusive Community. College Park, MD. Retrieved from https://www.aps.org/programs/lgbt/upload/LGBTClimateinPhysicsReport.pdf

Anthis, K. (2011). Is it the clicker, or is it the question? Untangling the effects of student response system use. *Teaching of Psychology*, *38*(3), 189–193.

Armbruster, P., Patel, M., Johnson, E., & Weiss, M. (2009). Active Learning and Student-centered Pedagogy Improve Student Attitudes and Performance in Introductory Biology. *CBE-Life Sciences Education*, *8*(3), 203–213. https://doi.org/10.1187/cbe.09-03-0025

Auchincloss, L. C., Laursen, S. L., Branchaw, J. L., Eagan, K., Graham, M., Hanauer, D. I., … Dolan, E. L. (2014). Assessment of Course-Based Undergraduate Research Experiences: A Meeting Report. *CBE Life Sciences Education*, *13*(1), 29–40. https://doi.org/10.1187/cbe.14-01-0004

Aughinbaugh, A. (2008). Who goes to college-evidence from the NLSY97. *Monthly Lab. Rev.*, *131*, 33.

Bamber, M. D., & Schneider, J. K. (2016). Mindfulness-based meditation to decrease stress and anxiety in college students: A narrative synthesis of the research. *Educational Research Review*, *18*, 1–32.

Banas, J. A., Dunbar, N., Rodriguez, D., & Liu, S.-J. (2011). A Review of Humor in Educational Settings: Four Decades of Research. *Communication Education*, *60*(1), 115–144. https://doi.org/10.1080/03634523.2010.496867

Barnes, M. E., Truong, J. M., & Brownell, S. E. (2017). Experiences of Judeo-Christian Students in Undergraduate Biology. *CBE-Life Sciences Education*, *16*(1), ar15. https://doi.org/10.1187/cbe.16-04-0153

Barr, D. A., Gonzalez, M. E., & Wanat, S. F. (2008). The leaky pipeline: Factors associated with early decline in interest in premedical studies among underrepresented minority undergraduate students. *Academic Medicine*, *83*(5), 503–511.

Barton, A., Beattie, M., Borissov, G., Bouhova-Thacker, E., Dearnaley, W., Fox, H., … Wharton, A. (2015). Search for the Standard Model Higgs boson produced in association with top quarks and decaying into bb in pp collisions at √s =8TeV with the ATLAS detector. *European Physical Journal C: Particles and Fields*, *75*. Retrieved from http://dx.doi.org/10.1140/epjc/s10052-015-3543-1

Bell, B. S., & Kozlowski, S. W. (2008). Active learning: effects of core training design elements on self-regulatory processes, learning, and adaptability. *Journal of Applied Psychology*, *93*(2), 296.

Berk, R. A. (1996). Student Ratings of 10 Strategies for Using Humor in College Teaching. *Journal on Excellence in College Teaching*, *7*(3), 71–92.

Bilimoria, D., & Stewart, A. J. (2009). "Don't Ask, Don't Tell": The Academic Climate for Lesbian, Gay, Bisexual, and Transgender Faculty in Science and Engineering. *NWSA Journal*, *21*(2), 85–103.

Bode, M., Drane, D., Kolikant, Y. B.-D., & Schuller, M. (2009). A clicker approach to teaching calculus. *Notices of the AMS*, *56*(2), 253–256.

Bong, M., & Skaalvik, E. M. (2003). Academic Self-Concept and Self-Efficacy: How Different Are They Really? *Educational Psychology Review*, *15*(1), 1–40. https://doi.org/10.1023/A:1021302408382

Bostani, M., Nadri, A., & Nasab, A. R. (2014). A study of the relation between mental health and academic performance of students of the Islamic Azad University Ahvaz branch. *Procedia-Social and Behavioral Sciences*, *116*, 163–165.

Bowden, A., Fox-Rushby, J. A., Nyandieka, L., & Wanjau, J. (2002). Methods for pre-testing and piloting survey questions: illustrations from the KENQOL survey of health-related quality of life. *Health Policy and Planning*, *17*(3), 322–330.

Brainard, S. G., & Carlin, L. (1998). A six-year longitudinal study of undergraduate women in engineering and science. *Journal of Engineering Education*, *87*(4), 369–375.

Braun, V., & Clarke, V. (2009). Coming out and negotiating heteronormativity in higher education. *Lesbian & Gay Psychology Review*, *10*(1), 3–7.

Braxton, J. M., Jones, W. A., Hirschy, A. S., & Hartley, H. V. (2008). The Role of Active Learning in College Student Persistence. *New Directions for Teaching and Learning*. https://doi.org/10.1002/tl.326

Braxton, J. M., Milem, J. F., & Sullivan, A. S. (2000). The influence of active learning on the college student departure process: Toward a revision of Tinto's theory. *The Journal of Higher Education*, *71*(5), 569–590.

Broeckelman-Post, M., Johnson, A., & Schwebach, J. R. (2016). Calling on students using notecards: engagement and countering communication anxiety in large lecture. *Journal of College Science Teaching*, *45*(5), 27.

Brownell, S. E., & Kloser, M. J. (2015). Toward a conceptual framework for measuring the effectiveness of course-based undergraduate research experiences in undergraduate biology. *Studies in Higher Education*, *40*(3), 525–544. https://doi.org/10.1080/03075079.2015.1004234

Brunner, M., Keller, U., Hornung, C., Reichert, M., & Martin, R. (2009a). The cross-cultural generalizability of a new structural model of academic self-concepts. *Learning and Individual Differences*, *19*(4), 387–403. https://doi.org/10.1016/j.lindif.2008.11.008

Brunner, M., Keller, U., Hornung, C., Reichert, M., & Martin, R. (2009b). The cross-cultural generalizability of a new structural model of academic self-concepts. *Learning and Individual Differences*, *19*(4), 387–403.

Bryant, J. (1980). Relationship between College Teachers' Use of Humor in the Classroom and Students' Evaluations of Their Teachers. *Journal of Educational Psychology*, *72*(4), 511–519.

Bryant, J., Alan, D. B., Silberberg, R., & Elliott, S. M. (1981). Effects of Humorous Illustrations in College Textbooks. *Human Communication Research*, *8*(1), 43–57. https://doi.org/10.1111/j.1468-2958.1981.tb00655.x

Burnham, K. P., & Anderson, D. R. (2003). *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*. Springer Science & Business Media.

Caballero, N. (2013, July 12). *Attitudes and beliefs towards LGBTQ community in a college campus* (Thesis). Retrieved from http://scholarworks.calstate.edu/handle/10211.9/2217

Calzo, J. P., Antonucci, T. C., Mays, V. M., & Cochran, S. D. (2011). Retrospective Recall of Sexual Orientation Identity Development Among Gay, Lesbian, and Bisexual Adults. *Developmental Psychology*, *47*(6), 1658–1673. https://doi.org/10.1037/a0025508

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Cech, E. A. (2015). LGBT Professionals' Workplace Experiences in STEM-Related Federal Agencies (p. 26.1094.1-26.1094.10). Presented at the 2015 ASEE Annual Conference & Exposition. Retrieved from https://peer.asee.org/lgbt-professionals-workplace-experiences-in-stem-related-federal-agencies

Cech, E. A., & Waidzunas, T. J. (2011). Navigating the heteronormativity of engineering: the experiences of lesbian, gay, and bisexual students. *Engineering Studies*, *3*(1), 1–24. https://doi.org/10.1080/19378629.2010.545065

Center for Collegiate Mental Health. (n.d.). *Center for Collegiate Mental Health 2017 Annual Report*. Penn State. Retrieved from http://ccmh.psu.edu/publications/

Chambliss, D. (2014). Learn your students' names. *Inside Higer Education*. Retrieved from Ed. www .insidehighered.com/views/2014/08/26/essay-calling-faculty-members - learn-their-students-names

Chen, X. (2009). Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education. Stats in Brief. NCES 2009-161. *National Center for Education Statistics*.

Chen, X. (2012). *STEM Attrition: College Students' Paths into and out of STEM Fields* (Statistical Analysis Report No. NCES 2014-001). Washington, DC: National Center for Education Statistics.

Chesebro, J. L., & McCroskey, J. C. (2001). The relationship of teacher clarity and immediacy with student state receiver apprehension, affect, and cognitive learning. *Communication Education*, *50*(1), 59–68. https://doi.org/10.1080/03634520109379232

Chi, M. T. H., & Wylie, R. (2014). The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes: Educational Psychologist: Vol 49, No 4. *Educational Psychologist*, *49*(4), 219–243.

Chi, M. T., Siler, S. A., & Jeong, H. (2004). Can tutors monitor students' understanding accurately? *Cognition and Instruction*, *22*(3), 363–387.

Christensen, L. J., & And Others. (1995). *Classroom Situations Which Lead to Student Participation*. Retrieved from https://eric.ed.gov/?id=ED391207

Christophel, D. M. (1990). The relationships among teacher immediacy behaviors, student motivation, and learning. *Communication Education*, *39*(4), 323–340. https://doi.org/10.1080/03634529009378813

Chrobot-Mason, D., Button, S. B., & DiClementi, J. D. (2001). Sexual Identity Management Strategies: An Exploration of Antecedents and Consequences. *Sex Roles*, *45*(5–6), 321–336. https://doi.org/10.1023/A:1014357514405

Cokley, K. O. (2002). Ethnicity, gender and academic self-concept: A preliminary examination of academic disidentification and implications for psychologists. *Cultural Diversity and Ethnic Minority Psychology*, *8*(4), 378–388. https://doi.org/10.1037/1099-9809.8.4.379

Collins, D. (2003). Pretesting survey instruments: An overview of cognitive methods | SpringerLink. *Quality of Life Research*, *12*(3), 229–238.

Cooper, K., & Brownell, S. (Under Review). Developing biology education research CUREs: Lessons learned and recommendations. *Journal of Microbiology and Biochemistry Education*.

Cooper, K., Krieg, A., & Brownell, S. E. (2018). Who perceives they're smarter? Exploring the influence of student characteristics on student academic self-concept. *Advances in Physiology Education.*

Cooper, K. M., Ashley, M., & Brownell, S. E. (2017). A bridge to active learning: A summer bridge program helps students maximize their active-learning experiences and the active-learning experiences of others. *CBE-Life Sciences Education, 16*(1), ar17.

Cooper, K. M., & Brownell, S. E. (2016a). Coming Out in Class: Challenges and Benefits of Active Learning in a Biology Classroom for LGBTQIA Students. *CBE-Life Sciences Education, 15*(3), ar37. https://doi.org/10.1187/cbe.16-01-0074

Cooper, K. M., Haney, B., Krieg, A., & Brownell, S. E. (2017). What's in a Name? The Importance of Students Perceiving That an Instructor Knows Their Names in a High-Enrollment Biology Classroom. *CBE Life Sciences Education, 16*(1). https://doi.org/10.1187/cbe.16-08-0265

Cooper, K. M., Soneral, P. A. G., & Brownell, S. E. (2017). Define Your Goals Before You Design a CURE: A Call to Use Backward Design in Planning Course-Based Undergraduate Research Experiences. *Journal of Microbiology & Biology Education, 18*(2). https://doi.org/10.1128/jmbe.v18i2.1287

Corbin, J., & Strauss, A. (2008). *Basics of Qualitative Research (3rd ed.): Techniques and Procedures for Developing Grounded Theory*. 2455 Teller Road, Thousand Oaks California 91320 United States: SAGE Publications, Inc. https://doi.org/10.4135/9781452230153

Corwin, L. A., Graham, M. J., & Dolan, E. L. (2015). Modeling Course-Based Undergraduate Research Experiences: An Agenda for Future Research and Evaluation. *CBE-Life Sciences Education, 14*(1), es1. https://doi.org/10.1187/cbe.14-10-0167

Covington, M. V. (1981). Strategies for smoking prevention and resistance among young adolescents. *The Journal of Early Adolescence*, *1*(4), 349–356.

Covington, M. V. (1992). *Making the Grade: A Self-Worth Perspective on Motivation and School Reform*. Cambridge University Press.

Creswell, J. W. (1994). *Research Design: Qualitative and Quantitative Approaches*. SAGE Publications.

Crisp, G., Nora, A., & Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution.

Crombie, G., Pyke, S. W., & Silverthorn, N. (2003). Students' Perceptions of Their Classroom Participation and Instructor as a Function of Gender and Context. *Journal of Higher Education, 74*(1), 51–76. https://doi.org/10.1353/jhe.2003.0001

Crouch, C. H., & Mazur, E. (2001). Peer instruction: Ten years of experience and results. *American Journal of Physics*, *69*(9), 970–977.

Culler, R. E., & Holahan, C. J. (1980). Test anxiety and academic performance: The effects of study-related behaviors. *Journal of Educational Psychology*, *72*(1), 16.

Dallaire, D. H. (2011). Effective use of personal response "clicker" systems in psychology courses. *Teaching of Psychology*, *38*(3), 199–204.

Dallimore, E. J., Hertenstein, J. H., & Platt, M. B. (2013). Impact of cold-calling on student voluntary participation. *Journal of Management Education*, *37*(3), 305–341.

D'Augelli, A. R., Hershberger, S. L., & Pilkington, N. W. (1998). Lesbian, gay, and bisexual youth and their families: disclosure of sexual orientation and its consequences. *The American Journal of Orthopsychiatry*, *68*(3), 361-371; discussion 372-375.

de Monteflores, C., & Schultz, S. J. (1978). Coming Out: Similarities and Differences for Lesbians and Gay Men. *Journal of Social Issues*, *34*(3), 59–72. https://doi.org/10.1111/j.1540-4560.1978.tb02614.x

Deeks, J. (1998). When can odds ratios mislead? *British Medical Journal*, *317*(7166), 1155. https://doi.org/10.1136/bmj.317.7166.1155a

DeFreitas, S. C. (2013). Academic Achievement in First Generation College Students: The Role of Academic Self-Concept. *Journal of the Scholarship of Teaching and Learning*, *13*(1), 57–67.

Deiter, R. (2000). The Use of Humor as a Teaching Tool in the College Classroom. *NACTA Journal*, *44*(2), 20–28.

Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering. (2012). The National Academies of Sciences, Engineering and Medicine. Retrieved from https://doi.org/10.17226/13362

Downs, V. C., Javidi, M. M., & Nussbaum, J. F. (1988). An analysis of teachers' verbal communication within the college classroom: Use of humor, self-disclosure, and narratives. *Communication Education*, *37*(2), 127–141. https://doi.org/10.1080/03634528809378710

Dugan, J. P., & Yurman, L. (2011). Commonalities and Differences Among Lesbian, Gay, and Bisexual College Students: Considerations for Research and Practice. *Journal of College Student Development*, *52*(2), 201–216. https://doi.org/10.1353/csd.2011.0027

Ebenezer, J. V., & Zoller, U. (1993). Grade 10 Students' perceptions of and attitudes toward science teaching and school science. *Journal of Research in Science Teaching*, *30*(2), 175–186. https://doi.org/10.1002/tea.3660300205

Eddy, S. L., & Brownell, S. E. (2016). Beneath the numbers: A review of gender disparities in undergraduate education across science, technology, engineering, and math disciplines. *Physical Review Physics Education Research*, *12*(2), 020106. https://doi.org/10.1103/PhysRevPhysEducRes.12.020106

Eddy, S. L., Brownell, S. E., Thummaphan, P., Lan, M.-C., & Wenderoth, M. P. (2015). Caution, Student Experience May Vary: Social Identities Impact a Student's Experience in Peer Discussions. *CBE-Life Sciences Education*, *14*(4), ar45. https://doi.org/10.1187/cbe.15-05-0108

Eddy, S. L., Brownell, S. E., Thummaphan, P., Lan, M.-C., & Wenderoth, M. P. (2015c). Caution, Student Experience May Vary: Social Identities Impact a Student's Experience in Peer Discussions. *CBE-Life Sciences Education*, *14*(4), ar45. https://doi.org/10.1187/cbe.15-05-0108

Eddy, S. L., Brownell, S. E., & Wenderoth, M. P. (2014). Gender gaps in achievement and participation in multiple introductory biology classrooms. *CBE Life Sciences Education*, *13*(3), 478–492. https://doi.org/10.1187/cbe.13-10-0204

Eddy, S. L., Converse, M., & Wenderoth, M. P. (2015). PORTAAL: A Classroom Observation Tool Assessing Evidence-Based Teaching Practices for Active Learning in Large Science, Technology, Engineering, and Mathematics Classes. *CBE-Life Sciences Education*, *14*(2), ar23. https://doi.org/10.1187/cbe.14-06-0095

Eddy, S. L., & Hogan, K. A. (2014). Getting Under the Hood: How and for Whom Does Increasing Course Structure Work? *CBE-Life Sciences Education*, *13*(3), 453–468. https://doi.org/10.1187/cbe.14-03-0050

Elicker, J. D., & McConnell, N. L. (2011). Interactive learning in the classroom: Is student response method related to performance? *Teaching of Psychology*, *38*(3), 147–150.

England, B. J., Brigati, J. R., & Schussler, E. E. (2017). Student anxiety in introductory biology classrooms: Perceptions about active learning and persistence in the major. *PloS One*, *12*(8), e0182506.

Etengoff, C., & Daiute, C. (2014). Family members' uses of religion in post–coming-out conflicts with their gay relative. *Psychology of Religion and Spirituality*, *6*, 33–43.

Eysenck, M. W., & Calvo, M. G. (1992). Anxiety and performance: The processing efficiency theory. *Cognition & Emotion*, *6*(6), 409–434.

Fassinger, R. E. (1991). The Hidden Minority: Issues and Challenges in Working with Lesbian Women and Gay Men. *The Counseling Psychologist*, *19*(2), 157–176. https://doi.org/10.1177/0011000091192003

Ferla, J., Valcke, M., & Cai, Y. (2009). Academic self-efficacy and academic self-concept: Reconsidering structural relationships. *Learning and Individual Differences*, *19*(4), 499–505. https://doi.org/10.1016/j.lindif.2009.05.004

Fletcher, J., & Stren, R. (1989). Language Skills and Adaptation: A Study of Foreign Students in a Canadian University: Curriculum Inquiry: Vol 19, No 3. *Curriculum Inquiry*, *19*, 294–308.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014a). Active learning increases student performance in science,

engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410–8415. https://doi.org/10.1073/pnas.1319030111

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014b). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410–8415.

Freeman, S., Theobald, R., Crowe, A. J., & Wenderoth, M. P. (2017). Likes attract: Students self-sort in a classroom by gender, demography, and academic characteristics. *Active Learning in Higher Education*, *18*(2), 115–126. https://doi.org/10.1177/1469787417707614

Frymier, A. B., Wanzer, M. B., & Wojtaszczyk, A. M. (2008). Assessing Students' Perceptions of Inappropriate and Appropriate Teacher Humor. *Communication Education*, *57*(2), 266–288. https://doi.org/10.1080/03634520701687183

Furnham, A. (2001). Self-estimates of intelligence: culture and gender difference in self and other estimates of both general (g) and multiple intelligences. *Personality and Individual Differences*, *31*(8), 1381–1405.

Gervais, M., & Wilson, D. S. (2005). The Evolution and Functions of Laughter and Humor: A Synthetic Approach. *The Quarterly Review of Biology*, *80*(4), 395–430. https://doi.org/10.1086/498281

Glaser, B. G. (1965). The Constant Comparative Method of Qualitative Analysis. *Social Problems*, *12*(4), 436–445. https://doi.org/10.2307/798843

Glaser, B. G., & Strauss, A. L. (2009). *The Discovery of Grounded Theory: Strategies for Qualitative Research*. Transaction Publishers.

Glaser, B. G., Strauss, A. L., & Strutzel, E. (1968). The Discovery of Grounded Theory; Strategies for Qualitative Research. *Nursing Research*, *17*(4), 364.

Glesne, C., & Peshkin, A. (1992a). *Becoming qualitative researchers: An introduction*. White Plains, NY: Longman.

Glesne, C., & Peshkin, A. (1992a). *Becoming qualitative researchers: An introduction*. Longman White Plains, NY.

Glesne, C., & Peshkin, A. (1992b). *Becoming qualitative researchers: An introduction*. White Plains, NY: Longman.

Glesne, C., & Peshkin, A. (1992b). *Becoming qualitative researchers: an introduction*. Longman.

Goffman, E. (1986). *Stigma: Notes on the Management of Spoiled Identity*. Touchstone. Retrieved from http://www.simonandschuster.com/books/Stigma/Erving-Goffman/9780671622442

Gomillion, S. C., & Giuliano, T. A. (2011). The Influence of Media Role Models on Gay, Lesbian, and Bisexual Identity. *Journal of Homosexuality*, *58*(3), 330–354. https://doi.org/10.1080/00918369.2011.546729

Good, C., Rattan, A., & Dweck, C. S. (2012). Why do women opt out? Sense of belonging and women's representation in mathematics. *Journal of Personality and Social Psychology*, *102*(4), 700–717. https://doi.org/10.1037/a0026659

Goodboy, A. K., Booth-Butterfield, M., Bolkan, S., & Griffin, D. J. (2015). The Role of Instructor Humor and Students' Educational Orientations inStudent Learning, Extra Effort, Participation, and Out-of-Class Communication. *Communication Quarterly*, *63*(1), 44–61. https://doi.org/10.1080/01463373.2014.965840

Goodstein, L. (2015, November 6). Mormons Sharpen Stand Against Same-Sex Marriage. *The New York Times*. Retrieved from https://www.nytimes.com/2015/11/07/us/mormons-gay-marriage.html

Gorham, J., & Christophel, D. M. (1990). The relationship of teachers' use of humor in the classroom to immediacy and student learning. *Communication Education*, *39*(1), 46–62. https://doi.org/10.1080/03634529009378786

Griffith, K. H., & Hebl, M. R. (2002). The disclosure dilemma for gay men and lesbians: "coming out" at work. *The Journal of Applied Psychology*, *87*(6), 1191–1199.

Grunspan, D. Z., Eddy, S. L., Brownell, S. E., Wiggins, B. L., Crowe, A. J., & Goodreau, S. M. (2016a). Males Under-Estimate Academic Performance of Their Female Peers in Undergraduate Biology Classrooms. *PLOS ONE*, *11*(2), e0148405. https://doi.org/10.1371/journal.pone.0148405

Grunspan, D. Z., Eddy, S. L., Brownell, S. E., Wiggins, B. L., Crowe, A. J., & Goodreau, S. M. (2016b). Males Under-Estimate Academic Performance of Their Female Peers in Undergraduate Biology Classrooms. *PLOS One*. https://doi.org/ttps://doi.org/10.1371/journal.pone.0148405

Grunspan, D. Z., Eddy, S. L., Brownell, S. E., Wiggins, B. L., Crowe, A. J., & Goodreau, S. M. (2016c). Males Under-Estimate Academic Performance of Their Female Peers in Undergraduate Biology Classrooms. *PLOS One*. https://doi.org/ttps://doi.org/10.1371/journal.pone.0148405

Guay, F., Ratelle, C. F., Roy, A., & Litalien, D. (2010). Academic self-concept, autonomous academic motivation, and academic achievement: Mediating and additive effects. *Learning and Individual Differences*, *20*(6), 644–653. https://doi.org/10.1016/j.lindif.2010.08.001

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*, *18*(1), 59–82.

Hackathorn, J., Garczynski, A. M., Blankmeyer, K., Tennial, R. D., & Solomon, E. D. (2011). All Kidding Aside: Humor Increases Learning at Knowledge and Comprehension Levels. *Journal of the Scholarship of Teaching and Learning*, *11*(4), 116–123.

Hanson, S. (2008). *Swimming against the tide: African American girls and science education*. Temple University Press.

Harper, N. W., & Daane, C. J. (1998). Causes and reduction of math anxiety in preservice elementary teachers. *Action in Teacher Education*, *19*(4), 29–38.

Heimberg, R. G., Brozovich, F. A., & Rapee, R. M. (2010). A cognitive behavioral model of social anxiety disorder: Update and extension. In *Social Anxiety (Second Edition)* (pp. 395–422). Elsevier.

Herek, G. M. (1988). Heterosexuals' attitudes toward lesbians and gay men: Correlates and gender differences. *The Journal of Sex Research*, *25*(4), 451–477. https://doi.org/10.1080/00224498809551476

Herek, G. M. (1994). Assessing Heterosexuals' Attitudes toward Lesbians and Gay Men: A Review of Empirical Research with the ATLG Scale. In *Lesbian and Gay Psychology: Theory, Research, and Clinical Applications* (pp. 206–228). Thousand Oaks: SAGE Publications, Inc. https://doi.org/10.4135/9781483326757

Herek, G. M., & Glunt, E. K. (1993). Interpersonal contact and heterosexuals' attitudes toward gay men: Results from a national survey. *The Journal of Sex Research*, *30*(3), 239–244. https://doi.org/10.1080/00224499309551707

HERZOG, T. R. (2009). Gender differences in humor appreciation revisited. *Humor*, *12*(4), 411–424. https://doi.org/10.1515/humr.1999.12.4.411

Hilton, S., & Phillips, F. (2010). Instructor-Assigned and Student-Selected Groups: A View from Inside. *Issues in Accounting Education*, *25*(1), 15–33. https://doi.org/10.2308/iace.2010.25.1.15

Holland, L., Matthews, T. L., & Schott, M. R. (2013). "That's so gay!" Exploring college students' attitudes toward the LGBT population. *Journal of Homosexuality*, *60*(4), 575–595. https://doi.org/10.1080/00918369.2013.760321

Hooghe, M., Claes, E., Harell, A., Quintelier, E., & Dejaeghere, Y. (2010). Anti-gay sentiment among adolescents in Belgium and Canada: a comparative investigation into the role of gender and religion. *Journal of Homosexuality*, *57*(3), 384–400. https://doi.org/10.1080/00918360903543071

Houser, M. L., Cowan, R. L., & West, D. A. (2007). Investigating a New Education Frontier: Instructor Communication Behavior in CD-ROM Texts—Do Traditionally Positive Behaviors Translate into This New Environment? *Communication Quarterly*, *55*(1), 19–38. https://doi.org/10.1080/01463370600998319

Hughes, W. J. (2000). PERCEIVED GENDER INTERACTION AND COURSE CONFIDENCE AMONG UNDERGRADUATE SCIENCE, MATHEMATICS, AND TECHNOLOGY MAJORS. *Journal of Women and Minorities in Science and Engineering*, *6*(2). https://doi.org/10.1615/JWomenMinorScienEng.v6.i2.40

Human Rights Campaign. (n.d.). The Cost of the Closet and the Rewards of Inclusion. Retrieved February 11, 2018, from https://www.hrc.org/resources/the-cost-of-the-closet-and-the-rewards-of-inclusion/

Inc, G. (n.d.). San Francisco Metro Area Ranks Highest in LGBT Percentage. Retrieved February 11, 2018, from http://news.gallup.com/poll/182051/san-francisco-metro-area-ranks-highest-lgbt-percentage.aspx

Ironsmith, M., Marva, J., Harju, B., & Eppler, M. (2003). Motivation and performance in college students enrolled in self-paced versus lecture-format remedial mathematics courses. *Journal of Instructional Psychology*, *30*(4), 276.

James, M. C. (2006). The effect of grading incentive on student discourse in peer instruction. *American Journal of Physics*, *74*(8), 689–691.

Jansen, M., Schroeders, U., & Lüdtke, O. (2014). Academic self-concept in science: Multidimensionality, relations to achievement measures, and gender differences. *Learning and Individual Differences*, *30*, 11–21. https://doi.org/10.1016/j.lindif.2013.12.003

Javidi, M. N., & Long, L. W. (1989). Teacher' use of humor, self-disclosure, and narrative activity as a function of experience. *Communication Research Reports*, *6*(1), 47–52. https://doi.org/10.1080/08824098909359831

Johnson, A. C. (2007). Unintended Consequences: How Science Professors Discourage Women of Color. *Science Education*, *91*, 805–821. https://doi.org/10.1002/sce.20208

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, *38*(5), 365–379.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative learning: Improving university instruction by basing practice on validated theory. *Journal on Excellence in University Teaching*, *25*(4), 1–26.

Jun Zhang, L. (2001). Exploring variability in language anxiety: Two groups of PRC students learning ESL in Singapore. *RELC Journal*, *32*(1), 73–91.

Kane, T. R., Suls, J., & Tedeschi, J. T. (1977). Humour as a Tool of Social Interaction. In *It's a Funny Thing, Humour* (pp. 13–16). Pergamon. https://doi.org/10.1016/B978-0-08-021376-7.50007-3

Kao, C., & Gansneder, B. (1995). An assessment of class participation by international graduate students. *Journal of College Student Development*, *36*(2), 132–140.

Kaplan, R. M., & Pascoe, G. C. (1977). Humorous Lectures and Humorous Examples: Some Effects upon Comprehension and Retention. *Journal of Educational Psychology*.

Karabenick, S. A. (2003). Seeking help in large college classes: A person-centered approach. *Contemporary Educational Psychology*, *28*(1), 37–58. https://doi.org/10.1016/S0361-476X(02)00012-7

Kelley, D. H., & Gorham, J. (1988). Effects of immediacy on recall of information. *Communication Education*, *37*(3), 198–207. https://doi.org/10.1080/03634528809378719

Kennedy, G. E., & Cutts, Q. I. (2005). The association between students' use of an electronic voting system and their learning outcomes. *Journal of Computer Assisted Learning*, *21*(4), 260–268.

Kerr, D. L., Santurri, L., & Peters, P. (2013). A comparison of lesbian, bisexual, and heterosexual college undergraduate women on selected mental health issues. *Journal of American College Health: J of ACH*, *61*(4), 185–194. https://doi.org/10.1080/07448481.2013.787619

Khalaila, R. (2015). The relationship between academic self-concept, intrinsic motivation, test anxiety, and academic achievement among nursing students: Mediating and moderating effects. *Nurse Education Today*, *35*(3), 432–438. https://doi.org/10.1016/j.nedt.2014.11.001

Kinnish, K. K., Strassberg, D. S., & Turner, C. W. (2005). Sex differences in the flexibility of sexual orientation: a multidimensional retrospective assessment. *Archives of Sexual Behavior*, *34*(2), 173–183. https://doi.org/10.1007/s10508-005-1795-9

Kitzinger, C. (n.d.). Heteronormativity in Action: Reproducing the Heterosexual Nuclear Family in After-hours Medical Calls, *52*(4), 477–498. https://doi.org/10.1525/sp.2005.52.4.477

Knight, J. K., Wise, S. B., & Southard, K. M. (2013a). Understanding Clicker Discussions: Student Reasoning and the Impact of Instructional Cues. *CBE-Life Sciences Education*, *12*(4), 645–654. https://doi.org/10.1187/cbe.13-05-0090

Knight, J. K., Wise, S. B., & Southard, K. M. (2013b). Understanding clicker discussions: student reasoning and the impact of instructional cues. *CBE-Life Sciences Education*, *12*(4), 645–654.

Koul, R., Roy, L., & Lerdpornkulrat, T. (2012). Motivational goal orientation, perceptions of biology and physics classroom learning environments, and gender. *Learning Environments Research*, *15*(2), 217–229.

Lamm, A. J., Shoulders, C., Roberts, T. G., Irani, T. A., Snyder, L. J. U., & Brendemuhl, J. (2012). The Influence of Cognitive Diversity on Group Problem Solving Strategy. *Journal of Agricultural Education*, *53*(1), 18–30.

Lammers, W., & Gillaspy, J. A. (2013). Brief Measure of Student-Instructor Rapport Predicts Student Success in Online Courses. *International Journal for the Scholarship of Teaching and Learning*, *7*(2). https://doi.org/10.20429/ijsotl.2013.070216

LGBT+ Physicists. (2013). Supporting LGBT+ Physicists: A Best Practices Guide for Departments. Presented at the AAS Working Group on LGBTIQ Equality., Washington, DC. Retrieved from http://lgbtphysicists.org/files/BestPracticesGuide.pdf

Liang, C. T. H., & Alimo, C. (2005). The Impact of White Heterosexual Students' Interactions on Attitudes Toward Lesbian, Gay and Bisexual People: A Longitudinal

Study. *Journal of College Student Development*, *46*(3), 237–250. https://doi.org/10.1353/csd.2005.0028

Lock, R. M., Hazari, Z., & Potvin, G. (2013). Physics career intentions: The effect of physics identity, math identity, and gender. *AIP Conference Proceedings*, *1513*(1), 262–265. https://doi.org/10.1063/1.4789702

Lombardi, E. (2009). Varieties of transgender/transsexual lives and their relationship with transphobia. *Journal of Homosexuality*, *56*(8), 977–992. https://doi.org/10.1080/00918360903275393

Lombardi, E. L., Wilchins, R. A., Priesing, D., & Malouf, D. (2001). Gender violence: transgender experiences with violence and discrimination. *Journal of Homosexuality*, *42*(1), 89–101.

London, B., Rosenthal, L., Levy, S. R., & Lobel, M. (2011). The Influences of Perceived Identity Compatibility and Social Support on Women in Nontraditional Fields During the College Transition. *Basic and Applied Social Psychology*, *33*(4), 304–321. https://doi.org/10.1080/01973533.2011.614166

Lopez, G., & Chism, N. (1993). Classroom Concerns of Gay and Lesbian Students: The Invisible Minority. *College Teaching*, *41*(3), 97–103.

Love, P. (1997). Contradiction and Paradox: Attempting to Change the Culture of Sexual Orientation at a Small Catholic College. *The Review of Higher Education*, *20*(4), 381–398. https://doi.org/10.1353/rhe.1997.0009

Love, P. G. (1998). Cultural Barriers Facing Lesbian, Gay, and Bisexual Students at a Catholic College. *The Journal of Higher Education*, *69*(3), 298–323. https://doi.org/10.2307/2649190

Lynch, O. (2002). Humorous communication: Finding a place for humor in communication research. *Communication Theory*, *12.4*, 423–445.

MacPhee, D., Farro, S., & Canetto, S. S. (2013). Academic Self-Efficacy and Performance of Underrepresented STEM Majors: Gender, Ethnic, and Social Class Patterns. *Analyses of Social Issues and Public Policy*, *13*(1), 347–369. https://doi.org/10.1111/asap.12033

Mahenthiran, S., & Rouse, P. J. (2000). The impact of group selection on student performance and satisfaction. *International Journal of Educational Management*, *14*(6), 255–265. https://doi.org/10.1108/09513540010348043

Mallow, J. V. (2006). *Science anxiety: research and action*. NSTA Press. Virginia, USA.

Marsh, H. W., & Craven, R. (1997). Academic Self-Concept: Beyond the Dustbowl. In *Phye G. (Ed.), Handbook of classroom assessment: Learning, achievement, and adjustment* (pp. 131–198). Orlando, FL: Academic Press. Retrieved from https://scholar.google.com/scholar_lookup?publication_year=1997&pages=131-198&author=H.W.+Marsh&author=R.+Cravenauthor=G.+Phye&title=Handbook+of+classroom+assessment:+Learning,+achievement,+and+adjustment

Marsh, H. W., & Craven, R. (1997). Academic self-concept: Beyond the dustbowl. *Handbook of Classroom Assessment: Learning, Achievement, and Adjustment*, 131–198.

Martin, R. A. (2010). *The Psychology of Humor: An Integrative Approach*. Elsevier.

McAllan, L. C., & Ditllo, D. (n.d.). Addressing the needs of lesbian and gay clients with disabilities. *Journal of Applied Rehabilitation Counseling*, *25*, 26–35.

McCarn, S. R., & Fassinger, R. E. (1996). Revisioning Sexual Minority Identity Formation: A New Model of Lesbian Identity and its Implications for Counseling and Research. *The Counseling Psychologist*, *24*(3), 508–534. https://doi.org/10.1177/0011000096243011

McKeachie, W. J. (1951). Anxiety in the college classroom. *The Journal of Educational Research*, *45*(2), 153–160.

McKeachie, W. J. (1984). Does anxiety disrupt information processing or does poor information processing lead to anxiety? *Applied Psychology*, *33*(2), 187–203.

McKinney, J. S. (2005). On the Margins: A Study of the Experiences of Transgender College Students. *Journal of Gay & Lesbian Issues in Education*, *3*(1), 63–76.

McKinney, M. E., Gatchel, R. J., & Paulus, P. B. (1983). The effects of audience size on high and low speech-anxious subjects during an actual speaking task. *Basic and Applied Social Psychology*, *4*(1), 73–87.

Mehrabian, A. (1971). *Silent Messages*. Retrieved from https://www.scribd.com/doc/98446772/Albert-Mehrabian-Silent-Messages-1971

Menzel, K. E., & Carrell, L. J. (1999). The impact of gender and immediacy on willingness to talk and perceived learning. *Communication Education*, *48*(1), 31–40. https://doi.org/10.1080/03634529909379150

Merriam-Webster. (2018). Humor | Definition of Humor by Merriam-Webster. Retrieved January 22, 2018, from https://www.merriam-webster.com/dictionary/humor

Micari, M., & Pazos, P. (2012). Connecting to the Professor: Impact of the Student–Faculty Relationship in a Highly Challenging Course. *College Teaching*, *60*(2), 41–47. https://doi.org/10.1080/87567555.2011.627576

Mintz, B., & Rothblum, E. D. (2013). *Lesbians in Academia: Degrees of Freedom*. Routledge.

Mishel, E. (2016). Discrimination against Queer Women in the U.S. Workforce: A Résumé Audit Study. *Socius*, *2*, 2378023115621316. https://doi.org/10.1177/2378023115621316

Misra, R., & McKean, M. (2000). College students' academic stress and its relation to their anxiety, time management, and leisure satisfaction. *American Journal of Health Studies*, *16*(1), 41.

Mizzi, R. C. (2013). “There aren’t any gays here”: encountering heteroprofessionalism in an international development workplace. *Journal of Homosexuality*, *60*(11), 1602–1624. https://doi.org/10.1080/00918369.2013.824341

Moore, A., Masterson, J. T., Christophel, D. M., & Shea, K. A. (1996). College teacher immediacy and student ratings of instruction. *Communication Education*, *45*(1), 29–39. https://doi.org/10.1080/03634529609379030

Morgan, E. M. (2013). Contemporary Issues in Sexual Orientation and Identity Development in Emerging Adulthood. *Emerging Adulthood*, *1*(1), 52–66. https://doi.org/10.1177/2167696812469187

Morse, J. M., Barrett, M., Mayan, M., Olson, K., & Spiers, J. (2002). Verification Strategies for Establishing Reliability and Validity in Qualitative Research. *International Journal of Qualitative Methods*, *1*(2), 13–22. https://doi.org/10.1177/160940690200100202

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: how situational cues affect women in math, science, and engineering settings. *Psychological Science*, *18*(10), 879–885. https://doi.org/10.1111/j.1467-9280.2007.01995.x

Nagoshi, J. L., Adams, K. A., Terrell, H. K., Hill, E. D., Brzuzy, S., & Nagoshi, C. T. (2008). Gender Differences in Correlates of Homophobia and Transphobia. *Sex Roles*, *59*(7–8), 521. https://doi.org/10.1007/s11199-008-9458-7

Nagy, G., Trautwein, U., Baumert, J., Köller, O., & Garrett, J. (2006). Gender and course selection in upper secondary education: Effects of academic self-concept and intrinsic value. *Educational Research and Evaluation*, *12*(4), 323–345. https://doi.org/10.1080/13803610600765687

National Organization for Gay and Lesbian Scientist and Technical Professionals. (n.d.). Queer Scientists of Historical Note – NOGLSTP. Retrieved February 11, 2018, from https://www.noglstp.org/publications-documents/queer-scientists-of-historical-note/

National Science Foundation/National Center for Science and Engineering. (n.d.). Women, Minorities, and Persons with Disabilities in Science and Engineering - NCSES - US National Science Foundation (NSF). Retrieved February 11, 2018, from https://www.nsf.gov/statistics/2017/nsf17310/

National Study of LGBTQ Student Success. (n.d.). National Study of LGBTQ Student Success. Retrieved February 14, 2018, from http://www.lgbtqsuccess.net/About.html

Neumann, D. L., Hood, M., & Neumann, M. M. (2009). Statistics? You Must be Joking: The Application and Evaluation of Humor when Teaching Statistics. *Journal of Statistics Education*, *17*(2), null-null. https://doi.org/10.1080/10691898.2009.11889525

Newman, B. S., & Muzzonigro, P. G. (1993). The effects of traditional family values on the coming out process of gay male adolescents. *Adolescence*, *28*(109), 213–226.

NIMH » Anxiety Disorders. (n.d.). Retrieved February 12, 2018, from https://www.nimh.nih.gov/health/topics/anxiety-disorders/index.shtml

Obergefell V Hodges (Supreme Court of the United States June 26, 2015). Retrieved from https://www.supremecourt.gov/opinions/14pdf/14-556_3204.pdf

Okebukola, P. A. (1986). Reducing anxiety in science classes: An experiment involving some models of class interaction. *Educational Research, 28*(2), 146–149.

Olson, S., & Riordan, D. G. (2012). Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics. Report to the President. *Executive Office of the President*.

Ommundsen, Y., Haugen, R., & Lund, T. (2005). Academic Self-concept, Implicit Theories of Ability, and Self-regulation Strategies. *Scandinavian Journal of Educational Research*, *49*(5), 461–474. https://doi.org/10.1080/00313830500267838

Ong, M., Wright, C., Espinosa, L., & Orfield, G. (2011). Inside the Double Bind: A Synthesis of Empirical Research on Undergraduate and Graduate Women of Color in Science, Technology, Engineering, and Mathematics. *Harvard Educational Review*, *81*(2), 172–209. https://doi.org/10.17763/haer.81.2.t022245n7x4752v2

Orlov, J. M., & Allen, K. R. (2014). Being who I am: effective teaching, learning, student support, and societal change through LGBQ faculty freedom. *Journal of Homosexuality*, *61*(7), 1025–1052. https://doi.org/10.1080/00918369.2014.870850

Osborne, J., & Collins, S. (2001). Pupils' views of the role and value of the science curriculum: A focus-group study. *International Journal of Science Education*, *23*(5), 441–467. https://doi.org/10.1080/09500690010006518

O'Sullivan, P. B., Hunt, S. K., & Lippert, L. R. (2004). Mediated Immediacy: A Language of Affiliation in a Technological Age. *Journal of Language and Social Psychology*, *23*(4), 464–490. https://doi.org/10.1177/0261927X04269588

Owens, M., Stevenson, J., Norgate, R., & Hadwin, J. A. (2008). Processing efficiency theory in children: Working memory as a mediator between trait anxiety and academic performance. *Anxiety, Stress, & Coping*, *21*(4), 417–430.

Page, B. (n.d.). Teacher feature learning your student's names: fun, fast, easy, and important. Retrieved February 16, 2018, from https://www.teachers.net/gazette/AUG02/page2.html

Pascarella, E. T., & Chapman, D. W. (1983). A multiinstitutional, path analytic validation of Tinto's model of college withdrawal. *American Educational Research Journal*, *20*(1), 87–102.

Pascarella, E. T., Duby, P. B., & Iverson, B. K. (1983). A text and reconceptualization of a theoretical model of college withdrawal in a commuter institution setting. *Sociology of Education*, 88–100.

Pascarella, E. T., Smart, J. C., & Ethington, C. A. (1986). Long-term persistence of two-year college students. *Research in Higher Education*, *24*(1), 47–71.

Pascarella, E. T., & Terenzini, P. T. (1983). Predicting voluntary freshman year persistence/withdrawal behavior in a residential university: A path analytic validation of Tinto's model. *Journal of Educational Psychology, 75*(2), 215.

Patridge, E. V., Barthelemy, R. S., & Rankin, S. R. (2014). FACTORS IMPACTING THE ACADEMIC CLIMATE FOR LGBQ STEM FACULTY. *Journal of Women and Minorities in Science and Engineering*, *20*(1). https://doi.org/10.1615/JWomenMinorScienEng.2014007429

Patton, M. Q. (2002). Two decades of developments in qualitative inquiry: A personal, experiential perspective. *Qualitative Social Work, 1*(3), 261–283.

Perez, R., DeBord, K., & Bieschke, K. (2000). Coming out: lesbian, gay, and bisexual identity development. In *Handbook of Counseling and Psychotherapy with Lesbian, Gay, and Bisexual Clients, ed*. Washington, DC: American Psychological Association.

Provine, R. (2001). *Laughter: A Scientific Investigation*. Penguin Books. Retrieved from https://books.google.com/books?hl=en&lr=&id=mTkVAAAAQBAJ&oi=fnd&pg=PT9&ots=QbQZWZX6VK&sig=56L128vYFNKaoe7_1MPPpm5YsJE#v=onepage&q&f=false

Quinn, D. M. (2006). Concealable versus conspicuous stigmatized identities. In *Stigma and Group Inequality: Social Psychological Perspectives* (pp. 83–103). Mahwah, NJ: Psychology Press.

Rankin, S. (2003). Campus Climate for LGBT People: A National Perspective. Presented at the National Gay and Lesbian Task Force Policy Institute, New York.

Rapee, R. M., & Barlow, D. H. (1991). *Chronic anxiety: Generalized anxiety disorder and mixed anxiety-depression.* Guilford Press.

Reetz, D. R., Krylowicz, B., & Mistler, B. (2014). The association for university and college counseling center directors annual survey. *Aurora*, *51*, 60506.

Rhoads, R. A. (1994). *Coming Out in College: The Struggle for a Queer Identity*. Greenwood Publishing Group.

Richmond, V. P., Gorham, J. S., & Mccroskey, J. C. (1987). The Relationship Between Selected Immediacy Behaviors and Cognitive Learning. *Annals of the International Communication Association*, *10*(1), 574–590. https://doi.org/10.1080/23808985.1987.11678663

Rocca, K. A. (2004). College student attendance: impact of instructor immediacy and verbal aggression. *Communication Education*, *53*(2), 185–195. https://doi.org/10.1080/03634520410001682447

Ross, S. E., Niebling, B. C., & Heckert, T. M. (1999). Sources of stress among college students. *Social Psychology, 61*(5), 841–846.

Russ, T., Simonds, C., & Hunt, S. (2002). Coming Out in the Classroom... An Occupational Hazard?: The Influence of Sexual Orientation on Teacher Credibility and

Perceived Student Learning. *Communication Education*, *51*(3), 311–324. https://doi.org/10.1080/03634520216516

Rust, P. C. (1993). "COMING OUT" IN THE AGE OF SOCIAL CONSTRUCTIONISM:: Sexual Identity Formation among Lesbian and Bisexual Women. *Gender & Society*, *7*(1), 50–77. https://doi.org/10.1177/089124393007001004

S Alatalo, & Poutiainen, A. (2016). Use of Humor in Multicultural Classroom. *Israeli Journal for Humor Research*, *5*(1), 65–79.

Safe Zone Project. (n.d.). Home page. Retrieved February 14, 2018, from http://thesafezoneproject.com/

Sandstrom, G. M., & Rawn, C. D. (2015). Embrace Chattering Students: They May Be Building Community and Interest in Your Class. *Teaching of Psychology*, *42*(3), 227–233. https://doi.org/10.1177/0098628315587620

Sarason, I. G. (1973). Test anxiety and cognitive modeling. *Journal of Personality and Social Psychology*, *28*(1), 58.

Science, A. A. for the A. of. (2015). Vision and change in undergraduate biology education: Chronicling change, inspiring the future. *A Report of the American Association for the Advancement of Science, Washington, DC.[Online.] Http://Visionandchange. Org*.

Seidel, S. B., Reggi, A. L., Schinske, J. N., Burrus, L. W., & Tanner, K. D. (2015). Beyond the Biology: A Systematic Investigation of Noncontent Instructor Talk in an Introductory Biology Course. *CBE Life Sciences Education*, *14*(4), ar43. https://doi.org/10.1187/cbe.15-03-0049

Seidel, S. B., & Tanner, K. D. (2013). "What if students revolt?"—Considering Student Resistance: Origins, Options, and Opportunities for Investigation. *CBE Life Sciences Education*, *12*(4), 586–595. https://doi.org/10.1187/cbe-13-09-0190

Sev'er, A., & Ungar, S. (1997). No Laughing Matter: Boundaries of Gender-Based Humour in the Classroom. *The Journal of Higher Education*, *68*(1), 87–105. https://doi.org/10.2307/2959937

Severiens, S. E., & Schmidt, H. G. (2009). Academic and social integration and study progress in problem based learning. *Higher Education*, *58*(1), 59. https://doi.org/10.1007/s10734-008-9181-x

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: why undergraduates leave the sciences*. Boulder (Colo.): Westview Press.

Shavelson, R. J., Hubner, J. J., & Stanton, G. C. (1976). Self-concept: Validation of construct interpretations. *Review of Educational Research*, *46*(3), 407–441.

Smith, J. L., Lewis, K. L., Hawthorne, L., & Hodges, S. D. (2013). When Trying Hard Isn't Natural: Women's Belonging With and Motivation for Male-Dominated STEM

Fields As a Function of Effort Expenditure Concerns. *Personality and Social Psychology Bulletin*, *39*(2), 131–143. https://doi.org/10.1177/0146167212468332

Smith, M. K., Wood, W. B., Adams, W. K., Wieman, C., Knight, J. K., Guild, N., & Su, T. T. (2009). Why peer discussion improves student performance on in-class concept questions. *Science*, *323*(5910), 122–124.

Smith, M. K., Wood, W. B., Krauter, K., & Knight, J. K. (2011). Combining peer discussion with instructor explanation increases student learning from in-class concept questions. *CBE-Life Sciences Education*, *10*(1), 55–63.

Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: the GAD-7. *Archives of Internal Medicine*, *166*(10), 1092–1097.

Springer, L., Stanne, M. E., & Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research*, *69*(1), 21–51.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, *69*(5), 797–811. https://doi.org/10.1037//0022-3514.69.5.797

Steele-Johnson, D., & Kalinoski, Z. T. (2014). Error framing effects on performance: Cognitive, motivational, and affective pathways. *The Journal of Psychology*, *148*(1), 93–111.

Stipek, D. J. (1993). Motivation to learn: From theory to practice.

Stout, J. G., Ito, T. A., Finkelstein, N. D., & Pollock, S. J. (2013). How a gender gap in belonging contributes to the gender gap in physics participation. *AIP Conference Proceedings*, *1513*(1), 402–405. https://doi.org/10.1063/1.4789737

Stowell, J. R., & Nelson, J. M. (2007). Benefits of electronic audience response systems on student participation, learning, and emotion. *Teaching of Psychology*, *34*(4), 253–258.

Strenta, A. C., Elliott, R., Adair, R., Matier, M., & Scott, J. (1994). Choosing and Leaving Science in Highly Selective Institutions. *Research in Higher Education*, *35*(5), 513–547.

Sun, J. C.-Y., Martinez, B., & Seli, H. (2014). Just-in-time or plenty-of-time teaching? Different electronic feedback devices and their effect on student engagement. *Journal of Educational Technology & Society*, *17*(2).

Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. *Cognitive Science*.

Tanner, K., & Allen, D. (2007). Cultural Competence in the College Biology Classroom. *CBE-Life Sciences Education*, *6*(4), 251–258. https://doi.org/10.1187/cbe.07-09-0086

Tanner, K., Chatman, L. S., & Allen, D. (2003). Approaches to cell biology teaching: cooperative learning in the science classroom—beyond students working in groups. *Cell Biology Education*, *2*(1), 1–5.

Tanner, K. D. (2011). Moving Theory into Practice: A Reflection on Teaching a Large, Introductory Biology Course for Majors. *CBE Life Sciences Education*, *10*(2), 113–122. https://doi.org/10.1187/cbe.11-03-0029

Tanner, K. D. (2013). Structure matters: twenty-one teaching strategies to promote student engagement and cultivate classroom equity. *CBE-Life Sciences Education*, *12*(3), 322–331.

Tatar, S. (2005). Why Keep Silent? The Classroom Participation Experiences of Non-native-English-speaking Students. *Language and Intercultural Communication*, *5*(3–4), 284–293. https://doi.org/10.1080/14708470508668902

Taylor, S. J., Bogdan, R., & DeVault, M. (2015). *Introduction to Qualitative Research Methods: A Guidebook and Resource*. John Wiley & Sons.

Teslow, J. L. (1995). Humor Me: A Call for Research. https://doi.org/10.1007/BF02300453

Theobald, E. J., Eddy, S. L., Grunspan, D. Z., Wiggins, B. L., & Crowe, A. J. (2017). Student perception of group dynamics predicts individual performance: Comfort and equity matter. *PloS One*, *12*(7), e0181336.

Thomas, C. E., Richmond, V. P., & McCroskey, J. C. (1994). The association between immediacy and socio-communicative style. *Communication Research Reports*, *11*(1), 107–114. https://doi.org/10.1080/08824099409359946

Thweatt, K. (1999). The impact of teacher immediacy, teacher affinity-seek- ing, and teacher misbehaviors on student-perceived teacher credibility. Presented at the National Communication Association, Chicago, IL.

Tinto, V. (1975). Dropout from Higher Education: A Theoretical Synthesis of Recent Research. *Review of Educational Research*, *45*(1), 89–125. https://doi.org/10.3102/00346543045001089

Tinto, V. (1997). Classrooms as communities: Exploring the educational character of student persistence. *The Journal of Higher Education*, *68*(6), 599–623.

Titsworth, B. S. (2001). The effects of teacher immediacy, use of organizational lecture cues, and students' notetaking on cognitive learning. *Communication Education*, *50*(4), 283–297. https://doi.org/10.1080/03634520109379256

Torok, S. E., McMorris, R. F., & Lin, W.-C. (2004). Is Humor an Appreciated Teaching Tool? Perceptions of Professors' Teaching Styles and Use of Humor. *College Teaching*, *52*(1), 14–20. https://doi.org/10.3200/CTCH.52.1.14-20

Townley, G., Katz, J., Wandersman, A., Skiles, B., Schillaci, M. J., Timmerman, B. E., & Mousseau, T. A. (2013). Exploring the Role of Sense of Community in the

Undergraduate Transfer Student Experience. *Journal of Community Psychology*, *41*(3), 277–290. https://doi.org/10.1002/jcop.21529

Trees, A. R., & Jackson, M. H. (2007). The learning environment in clicker classrooms: student processes of learning and involvement in large university-level courses using student response systems. *Learning, Media and Technology*, *32*(1), 21–40.

Trenor, J. M., Miller, M. K., & Gipson, K. G. (2011). Utilization of a think-aloud protocol to cognitively validate a survey instrument identifying social capital resources of engineering undergraduates. In *American Society for Engineering Education*. American Society for Engineering Education.

Trujillo, G., & Tanner, K. D. (2014). Considering the Role of Affect in Learning: Monitoring Students' Self-Efficacy, Sense of Belonging, and Science Identity. *CBE-Life Sciences Education*, *13*(1), 6–15. https://doi.org/10.1187/cbe.13-12-0241

Turner, J. R., & Gellman, M. (2013). *Encyclopedia of Behavioral Medicine.* Springer.

Udo, M. K., Ramsey, G. P., & Mallow, J. V. (2004). Science anxiety and gender in students taking general education science courses. *Journal of Science Education and Technology*, *13*(4), 435–446.

Uitto, A. (2014). Interest, attitudes and self-efficacy beliefs explaining upper-secondary school students' orientation towards biology-related careers. *International Journal of Science and Mathmatics Education*, *12*(6), 1425–1444. https://doi.org/10.1007/s10763-014-9516-2

Ulloth, J. K. (2002). The benefits of humor in nursing education. *The Journal of Nursing Education*, *41*(11), 476–481.

Ullrich, P. M., Lutgendorf, S. K., & Stapelton, J. T. (2003). Concealment of homosexual identity, social support and CD4 cell count among HIV-seropositive gay men. *Journal of Psychosomatic Research*. https://doi.org/10.1016/S0022-3999(02)00481-6

University of California, Davis. (n.d.). Get Educated. Retrieved February 14, 2018, from http://lgbtqia.ucdavis.edu/educated/index.html

Vaccaro, A. (2006). Gay, lesbian, bisexual, and transgender students. In: Understanding College Student Subpopulations: A Guide for Student Affairs Professionals, ed. (pp. 349–386). Presented at the National Association of Student Personnel Administrators, Washington, DC.

Vermunt, J. D. (1996). Metacognitive, cognitive and affective aspects of learning styles and strategies: A phenomenographic analysis. *Higher Education*, *31*(1), 25–50. https://doi.org/10.1007/BF00129106

Vision and Change in Undergraduate Biology Education: Chronicling Change, Inspiring the Future. (2015). American Association for the Advancement of Science.

Vitasari, P., Wahab, M. N. A., Othman, A., Herawan, T., & Sinnadurai, S. K. (2010). The relationship between study anxiety and academic performance among engineering students. *Procedia-Social and Behavioral Sciences*, *8*, 490–497.

Waldo, C. R., & Kemp, J. L. (1997). Should I come out to my students? An empirical investigation. *Journal of Homosexuality*, *34*(2), 79–94.

Walpole, M. (2003). Socioeconomic status and college: How SES affects college experiences and outcomes. *The Review of Higher Education*, *27*(1), 45–73.

Wanzer, M. B., Frymier, A. B., Wojtaszczyk, A. M., & Smith, T. (2006). Appropriate and Inappropriate Uses of Humor by Teachers. *Communication Education*, *55*(2), 178–196. https://doi.org/10.1080/03634520600566132

Watson, D., & Friend, R. (1969). Measurement of social-evaluative anxiety. *Journal of Consulting and Clinical Psychology*, *33*(4), 448.

Weeks, J. W., Heimberg, R. G., Fresco, D. M., Hart, T. A., Turk, C. L., Schneier, F. R., & Liebowitz, M. R. (2005). Empirical validation and psychometric evaluation of the Brief Fear of Negative Evaluation Scale in patients with social anxiety disorder. *Psychological Assessment*, *17*(2), 179.

Williams, M. M., & George-Jackson, C. (2014). USING AND DOING SCIENCE: GENDER, SELF-EFFICACY, AND SCIENCE IDENTITY OF UNDERGRADUATE STUDENTS IN STEM. *Journal of Women and Minorities in Science and Engineering*, *20*(2). https://doi.org/10.1615/JWomenMinorScienEng.2014004477

Willoughby, S. D., & Gustafson, E. (2009). Technology talks: Clickers and grading incentive in the large lecture hall. *American Journal of Physics*, *77*(2), 180–183.

Wilson, J. H., & Ryan, R. G. (2013). Professor–Student Rapport Scale: Six Items Predict Student Outcomes. *Teaching of Psychology*, *40*(2), 130–133. https://doi.org/10.1177/0098628312475033

Worthen, M. G. F. (2014). Blaming the Jocks and the Greeks?: Exploring Collegiate Athletes' and Fraternity/Sorority Members' Attitudes Toward LGBT Individuals. *Journal of College Student Development*, *55*(2), 168–195.

Wyer, M., Barbercheck, M., Geisman, D., Ozturk, H. O., & Wayne, M. (2001). *Female, science and technology: A reader in feminist science*. New York: Routledge.

Zakrajsek, T. (2007). Effective Teaching When Class Size Grows. *APS Observer*, *20*(5). Retrieved from https://www.psychologicalscience.org/observer/effective-teaching-when-class-size-grows

Ziv, A. (1988). Teaching and Learning with Humor: Experiment and replication. *The Journal of Experimental Education*, *57*(1), 4–15. https://doi.org/10

APPENDIX A

PERMISSION FROM CO-AUTHORS FOR CHAPTERS 2, 3, AND 4

Chapter 2 of this document was previously published in *CBE: Life Sciences Education* with co-author Sara Brownell, who has granted permission to include the manuscript in my thesis. Chapter 3 of this document was published in *Advances in Physiology Education* with co-authors Sara Brownell and Anna Krieg, both of whom granted permission to include the manuscript in my thesis. Lastly, Chapter 4 was previously published in *CBE: Life Sciences Education* with co-authors Sara Brownell, Bryan Haney, and Anna Krieg, all of whom granted permission to include this manuscript in my thesis.

APPENDIX B

IRB APPROVALS FOR CHAPTERS 2, 3, 4, 5, AND 6

LGBTQIA MICROAGGRESSIONS AND HETERONORMATIVITY IN UNDERGRADUATE BIOLOGY

APPROVAL: EXPEDITED REVIEW

Sara Brownell

Life Sciences, School of (SOLS)

-

Sara.Brownell@asu

.edu Dear Sara

Brownell:

On 10/6/2015 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	LGBTQA microaggressions and heteronormativity in undergraduate biology
Investigator:	Sara Brownell
IRB ID:	STUDY00003271
Category of review:	(6) Voice, video, digital, or image recordings, (7)(b) Social science methods, (7)(a) Behavioral research
Funding:	None
Grant Title:	None
Grant ID:	None

Documents Reviewed:	• Recruitment.9.29.pdf, Category: Recruitment Materials; • Consent.9.29.pdf, Category: Consent Form; • Interview Questions.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Survey.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • LGBTQA IRB.9.29.docx, Category: IRB Protocol;

The IRB approved the protocol from 10/6/2015 to 10/5/2016 inclusive. Three weeks before 10/5/2016 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 10/5/2016 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Katelyn Cooper
Katelyn Cooper

STUDENT PERCEPTIONS OF THEIR INTELLIGENCE COMPARED TO THEIR GROUPMATE'S INTELLIGENCE IN AN ACTIVE LEARNING BIOLOGY CLASS

APPROVAL: EXPEDITED REVIEW

Sara Brownell

Life Sciences, School of (SOLS)

-

Sara.Brownell@asu

.edu Dear Sara

Brownell:

On 9/19/2016 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Student perceptions of their intelligence compared to their groupmate's intelligence in an active learning biology class.
Investigator:	Sara Brownell
IRB ID:	STUDY00004939
Category of review:	(7)(b) Social science methods, (5) Data, documents, records, or specimens, (7)(a) Behavioral research
Funding:	None
Grant Title:	None
Grant ID:	None

Documents Reviewed:	• 16.9.16_IRB.docx, Category: IRB Protocol; • Example survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • 16.9.16_survey.consent.pdf, Category: Consent Form; • 16.9.16_demographics.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Debrief script.pdf, Category: Other (to reflect anything not captured above); • 16.9.16_survey.recruitment.pdf, Category: Recruitment Materials;

The IRB approved the protocol from 9/19/2016 to 9/18/2017 inclusive. Three weeks before 9/18/2017 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 9/18/2017 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Katelyn Cooper

Katelyn
Cooper
Anna Krieg

THE EXPERIECE OF STUDENTS WITH ANXIEYT IN ACTIVE LEARNING

CLASSROOMS

APPROVAL: EXPEDITED REVIEW

Sara Brownell

Life Sciences, School of (SOLS)

-

Sara.Brownell@asu

.edu Dear Sara

Brownell:

On 10/29/2016 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	The experience of students with anxiety in active learning classrooms
Investigator:	Sara Brownell
IRB ID:	STUDY00005221

Category of review:	(6) Voice, video, digital, or image recordings, (7)(b) Social science methods, (7)(a) Behavioral research
Funding:	Name: SOLS - Undergraduate Programs
Grant Title:	
Grant ID:	
Documents Reviewed:	• 16.10.25_IRB.docx, Category: IRB Protocol; • 16.10.27_survey.recruitment.pdf, Category: Recruitment Materials; • 16.10.27_survey.consent.pdf, Category: Consent Form; • 16.10.27_targeted.interview.recruitment.pdf, Category: Recruitment Materials; • 16.10.27_interview.consent.pdf, Category: Consent Form; • 16.10.27_Example survey questions.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • 16.10.27_selfselecting.interview.recruitment.pdf, Category: Recruitment Materials; • GAD7.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • 16.10.27_example.interview.questions.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); •

The IRB approved the protocol from 10/29/2016 to 10/28/2017 inclusive. Three weeks before 10/28/2017 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 10/28/2017 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Katelyn Cooper

Katelyn Cooper

UNDERGRADUATE PERCEPTIONS OF ACTIVE LEARNING

EXEMPTION GRANTED

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

Dear Sara Brownell:
On 12/11/2015 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Undergraduate perceptions of active learning
Investigator:	Sara Brownell
IRB ID:	STUDY00003626
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• 12.3.15_Recruitment.pdf, Category: Recruitment Materials; • CITI Training certificate for Brian Haney, Category: Other (to reflect anything not captured above); • 12.10.15_Consent.pdf, Category: Consent Form; • 12.3.15_IRB_BIO360.docx, Category: IRB Protocol; • Survey Questions, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Sample Interview Questions, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 12/11/2015.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Katelyn Cooper Katelyn Cooper

Sara Brownell Brian Haney

USE OF HUMOR IN COLLEGE CLASSROOMS

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

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

Dear Sara Brownell:
On 2/14/2017 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Use of humor in college classrooms
Investigator:	Sara Brownell
IRB ID:	STUDY00005725
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Email instructors will use to recruit students, Category: Recruitment Materials; • Protocol, Category: IRB Protocol; • Survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Consent form, Category: Consent Form;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 2/14/2017.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,
IRB Administrator

cc: Maryann Barnes Giovanni Badini Thomas Ruberto Roxann Jones Nicholas Massimo Anna Krieg Maryann Barnes Kali Mahrer Taija Hendrix Ashley Agloro Jacqueline Cala Annette Martin Michelle Stephens Bradley Eledge Edmond Lemon Joseph Barbera Sara Brownell Emily Webb Kailey Simonson