Distribution Agreement

Improving Undergraduate STEM Education through Hospitableness, Justice, Status, and Identity

By

Jennifer L. Hayward
Doctor of Philosophy

Sociology

____

Karen A. Hegtvedt
Advisor

____

Cassidy C. Puckett
Advisor

____

Cathryn Johnson
Committee Member

____

Richard B. Rubinson
Committee Member

____

Adria N. Welcher
Committee Member

Accepted:

____

Lisa A. Tedesco, Ph.D.
Dean of the James T. Laney School of Graduate Studies

____

Date

Improving Undergraduate STEM Education through Hospitableness, Justice, Status, and Identity

By

Jennifer L. Hayward
M.A., Emory University, 2019
B.A., University of Denver, 2013

Advisor: Karen A. Hegtvedt, PhD
Advisor: Cassidy C. Puckett, PhD

An abstract of
A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in Sociology
2020

Abstract

Improving Undergraduate STEM Education through Hospitableness, Justice, Status, and Identity
By Jennifer L. Hayward

Despite the plethora of studies on STEM persistence and the disparities within STEM since the 1990s, uneven progress has been made in substantially increasing women and underrepresented groups across STEM disciplines. The time students spend in their post-secondary education critically influences their future development as people, employees, citizens of a nation, consumers, activists, and many other identities and roles. I explore STEM students' experiences in the classroom, their perceptions of these experiences, as well as possible implications of their experiences on their persistence. Specifically, I focus on overlooked social psychological processes (see Xie, Fang, and Shauman 2015) unfolding in STEM classrooms as potential facilitators or inhibitors of continuation in such fields.

Broadly, my dissertation research investigates the influence of classroom dynamics on students' experiences in the classroom. More specifically, in Chapter 1 I investigate the pedagogical practices and conditions that shape the classroom climate students experience as they take their classes. In Chapter 2, I explore how students' experience of classroom dynamics through justice and status processes shape their emotions and perceptions of competence. Finally, in Chapter 3, I turn to students' development and solidification of a science identity, and the effects of a science identity on persistence in STEM.

The dissertation consists of three empirical papers stemming from data collected through observations and surveys in fall 2017 and fall 2018. I draw on data gathered from 137 hours of classroom observations in introductory biology and computer science classes over the Fall 2017 semester at a private university in the Southeast to provide the basis for Chapter 1 addressing classroom climate. Chapters 2 and 3 take a quantitative approach to students' experiences in the undergraduate STEM classroom relying on survey data collected from students (n=786) in biology and computer science over the course of two fall (2017, 2018) semesters. I use this survey data to examine how perceived classroom dynamics, assessed in terms of justice and status processes, affect emotional and cognitive responses (Chapter 2) and how those responses to the classroom facilitate or inhibit the development of science identities and persistence in STEM (Chapter 3).

Improving Undergraduate STEM Education through Hospitableness, Justice, Status, and Identity

By

Jennifer L. Hayward

M.A., Emory University, 2019
B.A., University of Denver, 2013

Advisor: Karen A. Hegtvedt, PhD
Advisor: Cassidy C. Puckett, PhD

A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy
in Sociology
2020

Acknowledgments

Committee – Karen Hegtvedt, Cassidy Puckett, Cathryn Johnson, Rick Rubinson, and Adria Welcher

Emory Faculty
Biology – Anita Corbett, Eladio Abreu, Megan Cole, Jaap De Roode, Pat Marsteller, Kate O'Toole, and Rachelle Spell;
Computer Science – Davide Fossati;

Emory Staff:
Pat Hamilton, Brandon Mitchell, and Kim Hall (For all their help with everything administrative!)

CFDE:
Donna Troka, Eric Weeks, Stephanie Parisi, Vialla Hartfield-Méndez, and Allison Adams

NS&FP:
Megan Friddle and Liz Alexander

Thank you to all of my family, including my late grandfather who always asked about how my dissertation was going.

All of my participants

All of my Emory peers who have helped and supported me along the way, and all of my non-Emory friends who smile and nod when I talk about my dissertation.

Additional
Emory's PDS program
The invaluable scholars who have provided feedback at conferences on my work in all of its various forms over the course of this project.

SSS, SWS-S, CFDE Summer Teaching Intensive

Table of Contents

List of Tables

List of Figures

List of Appendices

Introduction

At each successive educational level from primary school to college, there are fewer and fewer women and underrepresented minorities (URMs) than men and whites choosing Science, Technology, Engineering and Math (STEM) majors, and thus less likely to choose careers in traditional STEM domains (Watt 2006; Watt, Eccles, and Durik 2006). This pattern has traditionally been called the “leaky pipeline” (Oakes 1990; Stage and Maple 1996). Recent research, however, calls for more attention to factors that attract students to a particular major, rather than what causes students to “leak out” (Cannady, Greenwald, and Harris 2014; Lyon, Jafri, and St Louis 2012). Previous research has emphasized characteristics of students’ backgrounds (e.g., individual interests and aspirations, family characteristics, and residential neighborhoods) or structural aspects of education (e.g., tracking and school funding) to address this inequality (Riegle-Crumb et al. 2012; Ulriksen, Madsen, and Holmegaard 2010). Using the postsecondary education environment as the setting, this dissertation addresses the lack of diversity in STEM fields by focusing on overlooked social psychological processes (see Xie, Fang, and Shauman 2015) unfolding in STEM classrooms as potential facilitators of continuation in such fields.

Researchers use social psychological theories to illustrate how individual-level processes contribute to processes of social inequality related to gender, race, and class (among others) within social groups and organizations. I utilize social psychological theories about the effects of justice (Jost and Kay 2010) and status processes (Berger, Rosenholtz, and Zelditch Jr 1980), and identities (Stets and Burke 2003; Stryker 1980) which have been explored in workplace organizations and suggest ways these processes may operate in other organizations like educational institutions. Thus, the combination of sociology of education and social psychology can lead to new understandings of the issues that undergird these inequalities, and how they emerge in institutions like colleges and universities.

Broadly, my dissertation research investigates the influence of classroom dynamics on students' experiences in the STEM classroom. More specifically, in Chapter 1 I investigate the pedagogical practices and conditions that shape the classroom climate students experience as they take their classes. In Chapter 2, I explore how students' experience of classroom dynamics through their experiences of fair and unfair treatment, and status hierarchies in the classroom shape their emotions and perceptions of competence. Finally, in Chapter 3, I turn to students' development and solidification of a view of themselves as a scientist, and the effects of this identity as a scientist on persistence in STEM. Below, I describe more fully the key questions from each chapter, providing a brief overview of each. Then, I discuss how I combine sociology of education and social psychological perspectives using qualitative and quantitative work to address my questions.

Overview of Dissertation Methodology

The dissertation consists of three empirical papers stemming from data collected through observations and surveys in fall 2017 and fall 2018. I draw on data gathered from 137 hours of classroom observations in introductory biology and computer science classes over the Fall 2017 semester at a private university in the Southeast to provide the basis for Chapter 1 addressing classroom climate. Chapters 2 and 3 take a quantitative approach to students' experiences in the undergraduate STEM classroom relying on survey data collected from students (n=786) in biology and computer science over the course of two fall (2017, 2018) semesters. I use this survey data to examine how perceived classroom dynamics, assessed in terms of justice and status processes, affect emotional and cognitive responses (Chapter 2) and how those responses to the classroom facilitate or inhibit the development of science identities and persistence in STEM (Chapter 3).

Key Questions from Chapter 1: STEM Chilly Climate Literature

For the past 40 years, research on the “chilly climate” in STEM classes has emphasized exclusionary practices, including the subtle ways in which women and members of underrepresented minority (URMs) groups are treated differently in the classroom (Foster 1994; Hall and Sandler 1982, 1984; Miner et al. 2019). The chilly climate has been used to explain part of the high STEM attrition rates (Foster 1994; Morris 2003; Morris and Daniel 2008). Ample research demonstrates the many points at which women and URMs leave STEM fields at every junction (Allan and Madden 2006; Blickenstaff 2005; Flynn 2016; Miner et al. 2019; Monforti and Michelson 2008; Seymour and N. M. Hewitt 1997), highlighting the contributions of the chilly climate in STEM in pushing students out. As a response to these findings, numerous studies addressed the chilly climate by looking for ways to mitigate, or thaw the chilly climate (Friedrich, Sellers, and Burstyn 2008; Walton et al. 2015; Woodford, Kulick, and Atteberry 2015), while others focused on understanding the antecedents and evolution of the chilly climate in STEM over time (Maranto and Griffin 2011; Miner et al. 2019; Morris 2003).

While research shows that a chilly climate is exclusionary (Miner et al. 2019), and the presence of a chilly climate creates a negative experience for students (Johnson 2012; Morris and Daniel 2008), research leaves out other possible dimensions of classroom climate that make them more welcoming, especially for women and URMs. Enriching classrooms are not just those that have the absence of the chilly climate or classrooms that are just avoiding the negative effects. Researchers have not established the key features or factors of a STEM classroom that keeps students in the classroom, and helps students to feel positively about their experiences in their

STEM classes. To address this omission, in this study, I investigate identify what makes STEM classes appear to be more welcoming to women and URMs.

Chapter 1 qualitatively explores the types of classroom behaviors that create what I call a hospitable climate, which I define as one that draws students in, encourages engagement with the material, and creates a classroom environment where students feel safe and comfortable speaking up during class, without fear or intimidation from professors and peers. I examined features of STEM classrooms that may shape different dimensions of classroom climate. Overall, findings offered in Chapter 1 identify features like professor decision making, class size and the physical classroom design influences on interactional features such as pedagogy, exams and assessments, and the Learning Management Software (LMS), in the classroom, which shape the classroom climate. My broader contribution in Chapter 1 is discussing how to conceptualize the classroom climate. My findings contradict the implications of previous research that biology would have a more positive climate compared to computer science. My data indicate a more complicated picture, with characteristics of hospitableness and chilliness in both fields.

Key Questions from Chapter 2: Justice and Status Processes Literature

Students' in-class interactions and experiences may reinforce or generate race, gender, and class disparities among students who are equally prepared to pursue postsecondary STEM education, but do so at very unequal rates (Xie et al. 2015). Chapter 2 addresses how students perceive dynamics in STEM classrooms as a step in exemplifying the inhospitableness disproportionately felt by women and URMs. I move beyond the typical factors of students' background and characteristics shaping participation in STEM fields to consider whether students themselves perceive the dynamics in STEM classrooms, and associate these classroom dynamics with their broader thoughts about the field. To do so, I examine students' assessments of classroom dynamics, which in turn are likely to shape their immediate and long-term reactions to their STEM experiences. Specifically, guided by premises of justice (e.g., Jost and Kay 2010) and status processes (Berger et al. 1980), I focus on how students' perceptions of the social dynamics unfolding in their STEM classes shape their emotional responses to such classes and their own perceptions of competence.

Justice (or fairness) plays an important role in all social groups, and is especially important for students, as they spend the majority of their time in schools. Issues of justice arise in contexts comparing actual distributions of a valued resource from what might have been expected based on a particular distribution rule (distributive justice), the decision-making underlying the distribution (procedural justice), or the general treatment of potential recipients of the resource (interactional justice) (Jost and Kay 2010). People make assessments about whether distributed outcomes, processes of decision-making, or their interactions are "fair" or "unfair," which in turn stimulates affective (which comprise both positive and negative emotions), cognitive, and behavioral responses affecting interpersonal and organizational dynamics (Hegtvedt 2018). At the same time, status processes, which describe how individuals' social status characteristics (e.g., gender, race, socioeconomic status) affect the formation of hierarchies and influence patterns within groups (classrooms, students within a major) (Webster and Foschi 1988) stimulate similar affective, cognitive, and behavioral responses.

I hypothesized that students' experiences of these processes of justice and status shape their affective and cognitive responses to their classes. Lawler and Thye (2006) define affective responses, or emotions as something internal to an actor stemming from conditions or events external to the actor that take various forms, and tend to range from positive to negative. Competence involves individuals' cognitive knowledge and understanding of content, and is an especially important factor for choosing a major. Few studies bring together both affective and cognitive responses, despite the influence of both on future behaviors (Fiske and Taylor 2013; Turner and Stets 2005), such as continuation or discontinuation in STEM pursuits.

Results indicate that students' concerns about fairness of their outcomes (i.e., distributive justice regarding grades) and treatment from their professors (i.e., interpersonal justice) affect their emotional responses. My results suggest that to ensure students experience more positive than negative emotions during their experiences in STEM courses, faculty and departments train instructors to ensure interpersonal justice, and helping students to adjust the way they think about the importance of their grades. In addition, considerations of interpersonal justice (by both professors and peers) impact their assessments of competence. Findings from these surveys indicate that STEM students' concerns about their outcomes (i.e., fairness of grades) and treatment from their professors shape their emotional responses, whereas considerations of interpersonal justice (by both professors and peers) shape their assessments of competence. In other words, students' grades and fair treatment from professors and peers shape how competent students believe they are. Results also suggest that gender shapes both individuals' emotions and assessments of competence, while race only shapes competence and SES only shapes students' emotions. Overall, this suggests that justice and status processes in the classroom may ultimately matter for students' persistence in and for reducing disparities in STEM fields.

Key Questions from Chapter 3: Identity and Persistence Literature

I delve into the uneven progress in STEM research on the retention of women and URMs by investigating social psychological factors that specifically pertain to the development of students' science identities, arguing that these identities can be used to encourage persistence, and reduce existing educational inequalities. I draw upon identity development processes established within symbolic interactionism (Stets and Burke 2009) and highlight how the consequences of classroom dynamics—emotions experienced and competence perceived—

contribute to a science identity, and whether a science identity signals persistence in STEM. Research on the retention of students in STEM emphasize traditional individual-based approaches stressing students' individual level interests and aspirations, as well as family and contextual factors, such as their residential neighborhood and school (Xie et al. 2015) to explain disparities in STEM postsecondary fields (Cech et al. 2011; Riegle-Crumb et al. 2012; Soh, Samal, and Nugent 2007; Ulriksen et al. 2010). Previous research focused on an individual-based approach fails to explain the continuing disparities among women and underrepresented minorities, and fails to address how these important identities influence students' STEM educations.

Identities or self-definitions represent the various meanings attached to oneself by self and by others (Gecas and Burke 1995). Theories of identity are a useful lens to draw attention to the intersections of identities and the particular nature of STEM fields that makes it challenging for students to be included with a background other than white and male (Marlone and Barabino 2009). The few studies that do consider the importance of identities in science education are based on small qualitative samples and only focus on cognitive aspects of students experiences (Carlone and Johnson 2007). Thus, I build on Carlone and Johnson's (2007) framework based on identity work by Gee (2000) and include the impact of positive and negative emotions on students' science identities as well.

Specifically, I define a student's science identity as the sense that science is "right" for an individual or that an individual is "right" for science (Cech et al. 2011; Cole and Espinoza 2008; Correll 2001; Perez, Cromley, and Kaplan 2014). Recognizing that the science identity has previously been linked to stronger academic integration (Tinto 1975, 1987, 1988, 1998), I address whether such an identity signals persistence in STEM. Doing so extends research that addresses the types of individuals who progress into later careers in STEM disciplines (Heaverlo 2011; Lee 1998; Robnett 2013; Shapiro and Williams 2012) but rarely considers the role of the "science identity."

In Chapter 3 I examine how students' classroom responses impact their perceptions of their science identity, and how these identities may influence persistence. Findings from the analysis of responses to my surveys indicate that students' perceptions of their competence (and not their GPA) along with the received recognition (akin to the concept of verification from the symbolic interactionist framework) for their work shapes the degree to which students see themselves as scientists, and that students' science identity (and, unexpectedly, along with their negative emotions) cultivate students' intentions to enroll in future STEM courses. I argue research should expand the current focus on individual achievement and preparation processes (like overcoming deficits in prior knowledge) to understand how students' experience of the socialization process in the classroom impacts their ability to identify with and integrate into STEM fields, especially as such integration may depend on students' gender and race.

Overview of the Dissertation

Taken together, these three papers work toward integrating social psychological and sociology of education perspectives to address the enduring inequalities in the education system, and some potential avenues to reduce them. The three chapters of my dissertation utilize overlooked social psychological processes (see Xie et al. 2015) to address the lack of diversity in STEM fields by augmenting existing work regarding why women and students who are underrepresented minorities (URMs) persist in STEM fields at lower levels compared to men and whites. The results of my dissertation in the following chapters will elaborate on how to incorporate important findings and strategies in social psychology to the study of STEM students at the higher education level.

Works Cited

Allan, Elizabeth J. and Mary Madden. 2006. "Chilly Classrooms for Female Undergraduate Students: A Question of Method?" *The Journal of Higher Education* 77(4):684–711.

Berger, Joseph, Susan J. Rosenholtz, and Morris Zelditch Jr. 1980. "Status Organizing Processes." *Annual Review of Sociology* 6(1):479–508.

Blickenstaff, Jacob. 2005. "Women and Science Careers: Leaky Pipeline or Gender Filter?" *Gender and Education* 17(4):369–86.

Cannady, Matthew A., Eric Greenwald, and Kimberly N. Harris. 2014. "Problematizing the STEM Pipeline Metaphor: Is the STEM Pipeline Metaphor Serving Our Students and the STEM Workforce?" *Science Education* 98(3):443–60.

Carlone, Heidi B. and Angela Johnson. 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.

Cech, Erin, Brian Rubineau, Susan Silbey, and Caroll Seron. 2011. "Professional Role Confidence and Gendered Persistence in Engineering." *American Sociological Review* 76(5):641–66.

Cole, Darnell and Araceli Espinoza. 2008. "Examining the Academic Success of Latino Students in Science Technology Engineering and Mathematics (STEM) Majors." *Journal of College Student Development* 49(4):285–300.

Correll, Shelley J. 2001. "Gender and the Career Choice Process: The Role of Biased Self-Assessments." *American Journal of Sociology* 106(6):1691–1730.

Fiske, Susan T. and Shelley E. Taylor. 2013. *Social Cognition: From Brains to Culture*. Thousand Oaks, California: Sage.

Flynn, Daniel T. 2016. "STEM Field Persistence: The Impact of Engagement on Postsecondary

STEM Persistence for Underrepresented Minority Students." *Journal of Educational Issues* 2(1):185–214.

Foster, T. J., M. S. Foster, K. Flaugh, J. Kinschner, and N. Pidcock. 1994. An Empirical Test of Hall and Sandler's 1982 Report: Who Finds the Classroom Climate Chilly? Available online: https://eric.ed.gov/?id=ED373368 (accessed on 17 May 2018).

Friedrich, Katherine A., Sherrill L. Sellers, and Judith N. Burstyn. 2008. "9: Thawing the Chilly Climate: Inclusive Teaching Resources for Science, Technology, Engineering, and Math." *To Improve the Academy* 26(1):133–41.

Gecas, Viktor and Peter Burke. 1995. "Self and Identity." Pp. 41–67 in *Sociological Perspectives on Social Psychology. Boston, MA: Allyn and Bacon,* edited by K. S. Cook, G. A. Fine, and J. S. House. Boston, MA: Allyn and Bacon.

Gee, James Paul. 2000. "Chapter 3: Identity as an Analytic Lens for Research in Education." *Review of Research in Education* 25(1):99–125.

Hall, Roberta M. and Bernice R. Sandler. 1982. "The Classroom Climate: A Chilly One for Women?" in *Project on the Status of Women*. Washington D.C.: Association of American Colleges and Universities.

Hall, Roberta M. and Bernice R. Sandler. 1984. "Out of the Classroom: A Chilly Campus Climate for Women?" Washington D.C.: American Association of American Colleges and Universities.

Heaverlo, Carol Ann. 2011. "STEM Development: A Study of 6th-12th Grade Girls' Interest and Confidence in Mathematics and Science." PhD dissertation, Department of Education, University of Iowa. Retrieved from: https://search.proquest.com/pqdtglobal/docview/894337556/abstract/109BA73E53504198P

Q/112

Hegtvedt, Karen A. 2018. “Justice Frameworks.” Pp. 54–80 in *Contemporary Social Psychological Theories*, edited by P. J. Burke. Stanford, California: Stanford University Press.

Johnson, Dawn R. 2012. “Campus Racial Climate Perceptions and Overall Sense of Belonging among Racially Diverse Women in STEM Majors.” *Journal of College Student Development* 53(2):336–46.

Jost, John T. and Aaron C. Kay. 2010. “Social Justice: History, Theory, and Research.” Pp. 1122–65 in *Handbook of Social Psychology*, edited by S. T. Fiske, D. T. Gilbert, and G. Lindzey. Hoboken: John Wiley & Sons.

Lawler, Edward J. and Shane R. Thye. 2006. “Social Exchange Theory of Emotions.” Pp. 295–320 in *Handbook of the Sociology of Emotions*, edited by J. H. Turner and J. E. Stets. New York: Springer.

Lee, James Daniel. 1998. “Which Kids Can ‘Become’ Scientists? Effects of Gender, Self-Concepts, and Perceptions of Scientists.” *Social Psychology Quarterly* 61(3):199–219.

Lyon, Gabrielle H., Jameela Jafri, and Kathleen St Louis. 2012. “Beyond the Pipeline: STEM Pathways for Youth Development.” *Afterschool Matters* 16:48–57.

Maranto, Cheryl L. and Andrea E. C. Griffin. 2011. “The Antecedents of a ‘Chilly Climate’for Women Faculty in Higher Education.” *Human Relations* 64(2):139–59.

Marlone, K. and G. Barabino. 2009. “Narrations of Race in STEM Research Settings: Identity Formation and Its Determinants.” *Science Education* 93:486–510.

Miner, Kathi N., Samantha C. January, Kelly K. Dray, and Adrienne R. Carter-Sowell. 2019. “Is It Always This Cold? Chilly Interpersonal Climates as a Barrier to the Well-Being of Early-

Career Women Faculty in STEM." *Equality, Diversity and Inclusion: An International Journal* 38(2):226–45.

Monforti, Jessica Lavariega and Melissa R. Michelson. 2008. "Diagnosing the Leaky Pipeline: Continuing Barriers to the Retention of Latinas and Latinos in Political Science." *PS: Political Science & Politics* 41(01):161–66.

Morris, L. K. 2003. "The chilly climate for women: A literature review." Presented at the Annual Meeting of the Mid-South Educational Research Association, November, Biloxi, MI. Retrieved from ERIC database. (ED482555)

Morris, LaDonna K. and Larry G. Daniel. 2008. "Perceptions of a Chilly Climate: Differences in Traditional and Non-Traditional Majors for Women." *Research in Higher Education* 49(3):256–73.

Oakes, Jeannie. 1990. *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science.* Santa Monica, CA: The RAND Corporation.

Perez, Tony, Jennifer G. Cromley, and Avi Kaplan. 2014. "The Role of Identity Development, Values, and Costs in College STEM Retention." *Journal of Educational Psychology* 106(1):315.

Riegle-Crumb, Catherine, Barbara King, Eric Grodsky, and Chandra Muller. 2012. "The More Things Change, the More They Stay the Same? Prior Achievement Fails to Explain Gender Inequality in Entry into STEM College Majors over Time." *American Educational Research Journal* 49(6):1048–73.

Robnett, Rachael. 2013. "The Role of Peer Support for Girls and Women in the STEM Pipeline : Implications for Identity and Anticipated Retention." *International Journal of Gender,* *Science and Technology* 5(3):233–53.

Seymour, Elaine and Nancy M. Hewitt. 1997. *Talking About Leaving: Why Undergraduates Leave the Sciences.* Oxford: Westview Press.

Shapiro, Jenessa R. and Amy M. Williams. 2012. “The Role of Stereotype Threats in Undermining Girls’ and Women’s Performance and Interest in STEM Fields.” *Sex Roles* 66(3–4):175–83.

Soh, Leen-Kiat, Ashok Samal, and Gwen Nugent. 2007. “An Integrated Framework for Improved Computer Science Education: Strategies, Implementations, and Results.” *Computer Science Education* 17(1):59–83.

Stage, Frances K. and Sue A. Maple. 1996. “Incompatible Goals: Narratives of Graduate Women in the Mathematics Pipeline.” *American Educational Research Journal* 33(1):23–51.

Stets, Jan E. and Peter J. Burke. 2003. “A Sociological Approach to Self and Identity.” Pp. 128–52 in *Handbook of self and identity*, edited by M. R. Leary and J. P. Tangney. New York: Guilford.

Stryker, Sheldon. 1980. *Symbolic Interactionism*. Caldwell, NJ: The Blackburn Press.

Tinto, Vincent. 1975. “Dropout from Higher Education: A Theoretical Synthesis of Recent Research.” *Review of Educational Research* 45(1):89–125.

Tinto, Vincent. 1987. *Leaving College: Rethinking the Causes and Cures of Student Attrition.* Chicago: University of Chicago Press.

Tinto, Vincent. 1988. “Stages of Student Departure: Reflections on the Longitudinal Character of Student Leaving.” *The Journal of Higher Education* 59(4):438–55.

Tinto, Vincent. 1998. “Colleges as Communities: Taking Research on Student Persistence Seriously.” *The Review of Higher Education* 21(2):167–77.

Turner, Jonathan H. and Jan E. Stets. 2005. *The Sociology of Emotions*. Cambridge University Press.

Ulriksen, Lars, Lene Møller Madsen, and Henriette T. Holmegaard. 2010. "What Do We Know about Explanations for Drop out/Opt out among Young People from STM Higher Education Programmes?" *Studies in Science Education* 46(2):209–44.

Walton, Gregory M., Christine Logel, Jennifer M. Peach, Steven J. Spencer, and Mark P. Zanna. 2015. "Two Brief Interventions to Mitigate a 'Chilly Climate' Transform Women's Experience, Relationships, and Achievement in Engineering." *Journal of Educational Psychology* 107(2):468.

Watt, Helen M. G. 2006. "The Role of Motivation in Gendered Educational and Occupational Trajectories Related to Maths." *Educational Research and Evaluation* 12(4):305–22.

Watt, Helen M. G., Jacquelynne S. Eccles, and Amanda M. Durik. 2006. "The Leaky Mathematics Pipeline for Girls." *Equality, Diversity and Inclusion: An International Journal* 25(8):642.

Webster, Murray Jr. and Martha Foschi. 1988. "Overview of Status Generalization." Pp. 1–20 in *Status Generalization: New Theory and Research*, edited by M. J. Webster and M. Foschi. Stanford, California: Stanford University Press.

Woodford, Michael R., Alex Kulick, and Brittanie Atteberry. 2015. "Protective Factors, Campus Climate, and Health Outcomes among Sexual Minority College Students." *Journal of Diversity in Higher Education* 8(2):73.

Xie, Yu, Michael Fang, and Kimberlee Shauman. 2015. "Stem Education." *Annual Review of Sociology* 41:331–57.

Chapter 1: Looking Beyond Mitigating or Thawing the Chilly Climate: Creating a Hospitable Climate

Introduction

For the past 40 years, research on the "chilly climate" in science, technology, engineering, and math (STEM) classes has emphasized exclusionary practices, including the subtle ways in which women and members of underrepresented minority (URMs) groups are treated differently in the classroom (Foster 1994; Hall and Sandler 1982, 1984; Miner et al. 2019). A chilly climate helps explain the high STEM attrition rates (Foster 1994; Morris 2003; Morris and Daniel 2008). As a response to these findings, numerous studies addressed the chilly climate by looking for ways to mitigate, or thaw the chilly climate (Friedrich et al. 2008; Walton et al. 2015; Woodford et al. 2015), while others focused on understanding the antecedents and evolution of the chilly climate in STEM over time (Maranto and Griffin 2011; Miner et al. 2019; Morris 2003). Higher education research demonstrates that characteristics of institutional context and climate affect students' pursuit of and persistence in a STEM major (Chang et al. 2014; Hurtado and Carter 1997; Seymour and N. Hewitt 1997). However, "further research is needed to identify institutional factors that causally promote students' engagement with and achievement in STEM education" (Xie et al. 2015:8)

While research shows that a chilly climate is exclusionary (Miner et al. 2019), and the presence of a chilly climate creates a negative experience for students (Johnson 2012; Morris and Daniel 2008), research leaves out other possible dimensions of classroom climate that make them more welcoming, especially for women and URMs. Enriching classrooms are not just those that have the absence of the chilly climate or classrooms that are just avoiding the negative effects. Researchers have not established the key features or factors of a STEM classroom that keeps students in the classroom, and helps students to feel positively about their experiences in their

STEM classes. To address this omission, in this study, I seek to identify what makes STEM classes appear to be more welcoming to women and URMs.

To investigate the key features of STEM classrooms and to discover what draws students in, I engaged in 137 hours of classroom observations of introductory biology and computer science classes at a private university in the southeast. Relative to STEM fields generally, biology has greater diversity (Cheryan et al. 2017; National Science Foundation 2014), and research on computer science has struggled to investigate more than gender diversity (Larsen and Stubbs 2005). This study qualitatively explores the aspects of the classroom that help to explain the relative failure of STEM courses (Sjøberg and Schreiner 2005) to engage women and underrepresented minorities by investigating what lies behind the greater diversity in biology fields compared to the PS/E majors, like computer science.

Overall, my findings suggest that professor decision making, class size, the physical classroom design, pedagogy, exams and assessments, and the Learning Management Systems (LMS), operate as features of the classroom that help to keep underrepresented students engaged in STEM classrooms. Some of these features characterize the biology classes, and some characterize computer science, so each have elements of what I call ‘hospitable’ classrooms—which I define as one that draws students in, encourages engagement with the material, and creates a classroom environment where students feel safe and comfortable speaking up during class, without fear or intimidation from professors and peers. Based on these empirical findings, I argue for the broader reconceptualization and expansion of STEM classrooms from a singular dimension traditionally focused on the chilly climate, to include a second dimension of a hospitable climate. This expansion will help account for the wider range of classroom dynamics shaping inequities in STEM.

Chilliness and hospitableness are not simply opposites, but as separate dimensions of the classroom climate they each may range from "low" to "high." A classroom without much chilliness could be hospitable, but hospitable classrooms are more than just those that lack a chilly climate. Hospitable classrooms involve active amplification of classroom practices that specifically welcome women and URMs. This paper examines the differences between classroom practices to draw out and highlight the features of classes that vary across and within STEM classes. In doing so I address the question: *what are ways to think more broadly about the classroom climate and how it creates opportunities for inclusion or exclusion for students?*

I begin by contrasting STEM fields, focusing on biology and computer science. Then I describe the role of introductory STEM courses within a major and in terms of their impact on continued matriculation in a discipline. I introduce the section regarding factors that shape the nature of the climate in STEM courses by emphasizing the role of professor decision making. I then spell out institutional factors like class size and the physical classroom design as well as the behavior and pedagogy of faculty members and disciplinary practices.

Contrasting STEM Fields: Biology and Computer Science

Biology and computer science offer a comparison into possible contextual factors shaping inclusive and exclusive classroom dynamics that may shape entrance into and persistence in STEM. The literature suggests that women and minorities in STEM have improved slightly since the 1990s, but are still far from reaching parity (Chen 2009; Chen and Soldner 2013). In 2014, of the STEM Bachelor's degrees awarded, white students represented 58.6 percent of recipients, blacks represented 8.3 percent of recipients, Hispanics represented 11.5 percent of recipients, and Asians represented 9 percent of recipients. Women and racial minorities remain underrepresented in the STEM workforce, with the greatest disparities occurring in engineering, computer science, and the physical sciences (National Science Board 2016). Within STEM the literature (Bystydzienski and Bird 2006; Glass et al. 2013; US Census Bureau 2012), data from graduation rates and STEM degrees suggest that biology has more diverse representation by gender, race, and ethnicity compared to the physical science, engineering, math, and computer science fields. In 2016, Biological sciences represented 17.2 percent of these STEM degrees with white students earning 57.8 percent of biology degrees, blacks earning 6.9 percent, Hispanics earning 10.5 percent, and Asians earning 14.7 percent (National Science Board 2016).

In comparison, computer science in 2016 represented 8.8 percent of STEM degrees with white students earning 55.5 percent of computer sciences degrees, blacks earning 9.7 percent, Hispanics earning 9.7 percent, and Asians earning 9.5 percent (National Science Board 2016). Computer science serves as a case where representation of women and URMs has been decreasing in the larger workforce (Margolis and Fisher 2002; Margolis, Fisher, and Miller 1999). In contrast, in terms of race and gender, biology represents a case that has higher percentages of women and non-white individuals compared to the PS/E fields and computer science (Glass et al. 2013; US Census Bureau 2012).

Overall, students earning degrees in the biological sciences are more diverse in terms of gender and race compared to those earning degrees in computer science. Moreover, women make up 48 percent of workers in the biological, agricultural, and environmental life sciences occupations, but only 25 percent of the computer and mathematical sciences occupations. Researchers suggest that compared to PS/E, the biological sciences may be perceived as more open, inviting, and hospitable to those from traditionally underrepresented groups (Bystydzienski and Bird 2006). Thus, this study seeks to expand on this research by investigating the characteristics of classroom behaviors that may contribute to perceptions of classrooms as more open, inviting, and hospitable.

Introductory science courses, the focus of this study, are important because they act as gatekeepers (Seymour and N. M. Hewitt 1997; Tobias 1990). Gatekeeper courses refer to classes that generally represent the first course(s) required for matriculation into a major field of study (Tobias 1992). High levels of competition, large class sizes, and high failure rates characterize typical introductory or gatekeeper courses (Tobias 1992; Valkenburg 1990), which contribute to a chilly climate. Particularly for science, math, and engineering majors, these courses represent the first course in a series required to graduate from the major. In addition, these courses are the initial opportunity for students to learn more about the discipline, as well as the disciplinary norms and the ways each discipline approaches problems. Gatekeeper courses serve as the initial roadblock to persistence in the field as students who perform poorly are often restricted or prevented from proceeding to the next course in the sequence of the major (Tobias 1992). In addition, not succeeding in gatekeeper courses may prompt students, particularly those majoring in math, science, and engineering, to change their major, transfer to a new institution, or drop out of higher education entirely (Seymour 2002). Research finds that student performance in STEM gatekeeper courses helps to predict students who will graduate with a STEM degree, with a non-STEM degree, and those who will not graduate (Redmond-Sanogo, Angle, and Davis 2016), thus making introductory courses a useful place to observe students' initial foray into the STEM field in their undergraduate careers. The large class sizes common in these gatekeeper courses, as well as the pressure to do well in order to continue within the major contribute to a more chilly climate.

Factors Shaping the Climate of STEM Courses

Professors hold the institutional power to make most of the major decisions in building the classroom environment, so the actions of professors should be of special note in the role they have in the creation of a chilly or hospitable climate. In effect, instructors use their power to realize their own will, even over the resistance of others (Weber 1946) and thereby get students to do even what they might not want to do. Thus, for any course, how the decisions of the instructors shape the climate even before students enter the classroom. Of course, the power of the professor is limited and may manifest in behaviors and interactions within the classroom and to course content and the nature of assessment activities. I highlight these factors after first discussing institutional considerations often beyond instructors' control: class size and the physical environment of the classroom. Together, the institutional considerations and the factors under instructor's control contribute to the nature of the classroom climate that students experience.

Institutional Factors of Class Size and Classroom Physical Layout

The introductory STEM courses create challenges for faculty who must wrangle the large class sizes and the accompanying giant lecture halls necessary to accommodate these students. The physical environment of the classroom impacts students' achievement and experience in STEM courses (Hill and Epps 2009; Lei 2010; Martin 2002). Studies on the impact of the physical classroom environment will typically note factors such as tiered seating, customized lighting, upgraded desk and seat quality, noise control, ambient conditions, spatial layout, and functionality (Han et al. 2018; Hill and Epps 2009; Poysner 1983) among others. Studies that highlight the physical classroom environment typically distinguish between ambient conditions of the physical classroom, such as the level of air quality, temperature, humidity, odor, noise and lighting; compared to the spatial layout and functionality of the classroom environment such as seating areas, desks, chairs, tables, the size and shape of the classroom, projector, audio system and visual systems (TV screens, black/whiteboards).

Previous studies typically address students' satisfaction with the course (Han et al. 2018) and teaching evaluations (Hill and Epps 2009) based on the physical environment, yet little research elaborates on how these structures create challenges for faculty in terms of the classroom activities and interactions that are feasible within the physical constraints of the classroom. The typical STEM introductory course takes place in a large lecture hall with immobile desks and seating, and in spaces that are typically designed to focus attention on the front of the room, and the faculty member, and thus are not designed ideally for group work or interactions among students. Thus, I ask: *How does the physical layout of the classroom affect the range of pedagogical practices employed by the professor to engage students in the course material and the STEM field in general?*

Behaviors and Pedagogical Practices of Professors

Faculty and Student Interaction Dynamics. Faculty members are among the most influential socializing agents for college students (Astin 1984; Ewell and Jones 1996; Pascarella and Smart 1985; Tinto 1987, 1998). Influence from faculty members can be both positive and negative based on the *type* and *quality* of interactions between students and faculty. What instructors do in the classroom—their behaviors toward students and pedagogical practices—creates the nature of the climate. The chilly climate literature identifies faculty behaviors such as interrupting students, discouraging classroom participation, preventing students from seeking help outside of class, undermining confidence, and devaluing women and racial/ethnic minorities and their work (Foster 1994; Hall and Sandler 1982, 1984). In enacting such behaviors, faculty signal to students lower expectations for women than for men (and for racial/ethnic minorities compared to whites), which in turn limit students' development (Miner et al. 2019; Morris 2003).

The behaviors that specifically single out or ignore students due to their gender (Lee 1998; Pietri et al. 2018) or race (Marlone and Barabino 2009; Riegle-Crumb and King 2010) may cause those students to feel less confident about their abilities, as well as their place within the larger college community (Hall and Sandler 1982, 1984).

Behaviors associated with the chilly climate can also prime students to be more aware of negative stereotypes that professors (and other students) may hold about women and underrepresented racial minorities, and further reduce students' confidence in their abilities. Stereotype threat processes (Steele and Aronson 1995) explain how negative stereotypes of particular categories of students result in academic underperformance. Experimental research on stereotype threat demonstrates that gender and racial stereotypes and bias deter women's and URMs STEM interest and achievement (Aronson, Quinn, and Spencer 1998; Shapiro and Williams 2012; Spencer, Steele, and Quinn 1999). For example, negative stereotypes that impugn women's math and science abilities create fear of confirming the stereotype, which then inhibits performance (Good, Aronson, and Inzlicht 2003). Studies reveal that such inhibited performance creates intellectual gaps between men and women, and among white, black, and Hispanic students on math and science standardized tests (Spencer et al. 1999; Steele and Aronson 1995). The prevalence of a STEM achievement gap among minority students (Haak et al. 2011; Olszewski-Kubilius et al. 2017) stems, in part, from the presence of stereotype threats (Appel and Kronberger 2012; Spencer et al. 1999; Steele and Aronson 1995).

While evoking stereotype threats exacerbate the chilly climate, other studies suggest behaviors that can ameliorate such threats. For example, amelioration unfolds when instructors help students to see their abilities as malleable (Good et al. 2003), affirm a valued attribute (Martens et al. 2006), or indicate to students that difficulties with exams are normal, and everyone has the ability to learn and succeed (Aronson, Cohen, and McColskey 2009). Such actions contribute to students' feelings of belonging and confidence in their abilities, which are crucial parts of the foundation for their unfolding classroom interactions with their professors and other students.

Previous findings also indicate that faculty can positively shape college classroom climates by frequently calling on students directly, providing informal feedback and encouragement, making eye-contact, remembering students' names, and selecting students to serve as assistants (Hall and Sandler 1982, 1984). Drawing from non-STEM research on college demonstrates that frequent interactions with faculty enhance students' persistence and retention in colleges and universities (Hernandez 2000; Jackson, Smith, and Hill 2003; Pascarella and Terenzini 2005), in addition to increasing students' academic performance (Anaya and Cole 2001; Cotten and Wilson 2006; Dika 2012) and aspirations for graduate school (Kim 2010).

The research applied specifically to STEM is more limited, but indicates that the effect of faculty support differs for men and women, and also highlights the importance of *positive* faculty interactions, which matter more than the overall frequency of interactions (Kim and Sax 2018). That is, students benefit much more by having one positive faculty interaction than if they had multiple neutral or negative faculty interactions. Nonetheless, actions that induce a more positive classroom climate rarely characterize college level STEM classrooms. STEM students report perceiving their classes as competitive, unwelcoming, and cold given to instructors' emphasis on research and restricted opportunities for student-faculty interactions (Gainen 1995; Seymour and N. M. Hewitt 1997; Strenta et al. 1994), requiring research into how these behaviors manifest in the classroom and contribute to chilly or hospitable climates. However, research is lacking on specific information that distinguishes *how* faculty-student interactions in STEM can be structured to positively create a more hospitable classroom environment. Thus, I ask: *How do interactions between professors, students and their peers create the classroom climate that students experience?*

Course Content and Assessment. Beyond the actual dynamics in the classroom, professors control the content of the course and assessment strategies. Each of these considerations also signal aspects of the course climate that students experience. Professors decide the structure of the syllabus, how to cover the material in a class session, as well as over the course of the semester. Yet, selecting content and presenting it can be problematic when it is colored by race and class stereotypes that influence both the way that professors choose to teach information to students, as well as the type of information that they teach (Carter 2012; Kruse and Louis 2009; Lewis 2003a, 2003b; McDonough 1997). The subtle influence of negative stereotypes about categories of students may contribute to experiencing a chillier climate for those students compared to the experience of others.

The way subjects are taught, and how they successfully (or fail to) engage students is also important to the classroom climate. Social relevance (i.e., the real world application) in choosing major and career options is more important for women than for men (Kyte and Riegle-Crumb 2017). Yet, as they are generally taught, science classes obscure the social relevance of science by primarily emphasizing the memorization of decontextualized facts and concepts (Archer et al. 2010; Badri et al. 2016; Osborne, Simon, and Collins 2003). The combination of STEM courses' obscured social relevance along with cultural messages that deemphasize women and racial minority students' ability to succeed in the sciences may further weaken students' interest in and desire to pursue a STEM major or career. Previous research suggests part of encouraging persistence in STEM is through student engagement (Flynn 2016; Kuh 2003; Ohland et al.

2008), which I argue contributes towards a more hospitable climate. Given the strong influence of academic engagement on a student's likelihood to persist, having a sense of connection to peers and faculty within gatekeeper courses may substantially bear on a student's decision to reenroll at the same institution (Eagan and Jaeger 2008).

How professors decide to assess students' knowledge, and what they require their students to do to demonstrate their knowledge or mastery of the material are additional pedagogical practices contributing to climate. The issue of testing is also closely related to stereotype threat, as students' performance on exams is often used to explain the achievement gaps between men and women and students from different racial backgrounds. Previous research indicates that how well students are able to do on exams depends on the types of testing and questions asked on exams (Wright et al. 2016).

Other research also suggests that differences in achievement on exams can be explained by the different study habits that are necessary for college level courses in STEM disciplines (Migliaccio et al. 2009). Professors who are unaware of (or ignore) differences in student preparation especially based on racial or class stereotypes may fail to equip their students with the skills to be successful on assessments and exams (by making students aware of college study habits and how to answer "high-level" questions), thus creating a classroom environment that is more challenging than necessary for students. Students who enter college less prepared (typically URMs from poor high schools (Hilts, Part, and Bernacki 2018; Hu and Wolniak 2013; Riegle-Crumb and King 2010)) may find the workload and study expectations overwhelming, creating a more negative classroom climate. Women and URM students entering college may find that they do not know how to study for college level STEM exams, which ask them to answer questions beyond the "low-level" questions (Crowe, Dirks, and Wenderoth 2008; Momsen et al. 2010,

2013) according to Bloom's taxonomy of cognitive domains (Bloom 1956). In essence, first-year students often have difficulty isolating the important information that is key for them to know and understand, and will be relevant to their future areas of study or later in their lives or career. Research suggests that college students will not learn successfully when their primary study habit and strategy is to try to memorize all of the information, students need to learn to study by asking themselves questions of a "higher-order" that require a deeper understanding of the inter-related aspects of the class material (Crowe et al. 2008; Momsen et al. 2010, 2013). Professors can ensure students are aware of this information by structuring lectures to emphasize study strategies and habits, as well as how the course-information is inter-related (Crowe et al. 2008).

Professors structure the classroom environment experienced by students through their pedagogical practices, in terms of their preferences in terms of the frequency of lecturing, discussions, assessment, demonstrations, individual work, hands-on or lab work, small group work (Hazari et al. 2010; Hazari, Sadler, and Sonnert 2013). Professors who are more aware of issues like stereotype threat (and emphasizing that everyone can be good at STEM) and the importance of helping students learn how to study and the social relevance of materials can serve as more effective socializing agents for students, thus creating a more hospitable climate. However, previous research does not offer specifics for how to combine these elements of the classroom to help students. This leads me to ask: *How do professors' emphasis of information in lectures and assessment of students' competence contribute to the creation of an environment that emphasizes all students' ability to succeed in STEM?*

Positionality of Professors and Disciplinary Practices

In order to encourage students to persist in STEM, faculty and departments that seek to need to help provide students with resources that make them aware of disciplinary practices and expectations (i.e., the hiring process, and the importance of hiring for diverse identities that provide STEM role models for all types of students. However, previous research does not address how faculty who are diverse can leverage their identities in interactions and classes to create a more hospitable climate.

An important organizational matter that influences students' experience both within a specific class, but also across classes within the academic STEM department is who gets hired as an instructor. Professors bring many demographic identities into the classroom, their race, gender, and SES, among others. Professors' identities serve as the basis of their positionality in the classroom, and their ability to relate to the demographic experiences of their students. Due to issues of cultural matching, many departments may end up with professors who are very similar to each other, either due to the importance of cultural "fit" within a department (Allen, Smith, and Ransdell 2019; Rivera 2012) or because there are fewer diverse undergraduates (and graduate students) who "make it" to become a professor (Hartlep et al. 2017; Posselt 2016; Schnitman 2014).

Departments that lack diverse faculty create classroom climates where only some students are able to "match" with their professors. Students who perceive themselves as having had similar experiences as their professors (i.e., see their teachers as a role model of someone who will understand them racially, or based on class or gender) show improved academic achievement and motivation (Gehlbach et al. 2016; Wilson and Buttrick 2016), and feelings of competence and happiness (Froiland, Worrell, and Oh 2019). In addition, women and URM professors, serve as vital role models that show women and URMs that someone like them can succeed in an academic career in STEM (Basit 2012; Lockwood 2006). While much research demonstrates that similarities between faculty members and students have important future benefits (Eccles et al. 1993), research fails to demonstrate the ways faculty members can intentionally leverage these experiences and identities in efforts to positively structure the classroom environments.

The shift from secondary school to colleges and universities can be challenging for all students insofar as they must learn behavioral norms for succeeding in the institution as well as the substantive content of disciplines. Recent research argues for an expansion of traditional arts-based conceptualization of cultural capital to one that includes scientific forms of cultural and social capital called “science capital” (Archer, DeWitt, and Willis 2014). Science capital derives from Bourdieu's (1977) distinction of capital as a theoretical lens to understand differences in access to skills and resources that can explain differential patterns of aspiration and education. Building on this, science capital represents a set of properties that enable individuals to receive recognition from other members of a scientific field such as: scientific literacy and access to plentiful, high quality, science-related cultural and social resources (Archer et al. 2015). Expectations of behaviors in STEM are based on this “science” capital (Archer et al. 2015), which may add constraints for those who are not white men to fit into individual’s expectations for what a “science person” is supposed to look and act like (Cheryan, Plaut, et al. 2013; Cheryan, Master, and Meltzoff 2015; Thomson, Zakaria, and Radut-Taciu 2019). Thus, I ask *how do professors structure the classroom material to help students acclimate to the expectations of their behavior created by disciplinary cultures?*

Methods/Data

Overview of the Observation Site

To investigate how the classroom climate creates greater inclusion or exclusion for students I selected biology and computer science classes as cases that might differ and offer an example of biology as a more inclusionary case and computer science as a more exclusionary case. Over the course of the fall 2017 semester I observed all offered sections of students (n=678) in introductory biology (4) and computer science (3) at a private university in the Southeast US. This university was selected for its diverse student population by race, and as a site where the introductory courses did not have any pre-requisites or specific intro courses segregating students by major or non-major. In addition, R1 schools in particular perform better than public institutions in students' persistence and degree completion rates in STEM fields, while also producing students who are actively recruited to work in STEM fields (Rine 2014). I selected introduction sections to address limited research on student retention about how specifically introduction or gatekeeper courses influence students' decisions to remain enrolled at an institution. Observational data allowed me to compare different classroom formats that exist between biology and computer science courses to investigate possible reasons for the relative lack of diversity in national-level data for students in computer science compared to biology.

Across these seven classes multiple faculty members (n=5) taught multiple sections of the same course. The faculty members all had between 9-15 years of teaching experience. The same professor (a white man) taught all three sections of the computer science introduction course I observed. For biology I observed four different professors, one white man, two white women, and a black man who taught sections of the biology introduction course in the same room. The private university enrolls about 15, 252 students. Yearly tuition, assuming a full course load per semester, for 2015-16 was $46,314 tuition. In the 2018-19 academic year, this university has 41 percent white (non-Hispanic) students, 19 percent Asian, 17 percent non-resident international students, 8 percent black (non-Hispanic) students, and 9 percent Hispanic/Latino students (with 4 percent identifying as multiracial and 2 percent unknown). Table 1.1 shows the racial and gender representation of enrolled and major students in the biology and computer science department. In

2019, around 1,900 bachelor's degrees were awarded, with 338 students with a degree concentration in biology, and 38 in computer science.

[Table 1.1 about here]

Data Relevant to Research Questions

To investigate the classroom climate and the structural features of the environment in which students experience their STEM education, I observed interactions and class activities among professors and students, as well as more informal discussions with professors during staff meetings and students before and after the class. I conducted observations to provide contextual information about the courses, and the everyday experiences of students as they complete the course. The professor announced my presence when I started observing the course. I introduced myself as a Sociology researcher observing dynamics of the classroom. As I was observing large introduction courses, the classes were large, about 80 students in each class.

To look at the effects of professor decision making, I took note of elements of Teacher-Focused Instruction, that is, the number of times and the amount of time that professors spent: lecturing; on assessment; working out problems writing; drawing; annotating; individualized instruction; facilitating discussion; on administrative tasks; reading from a text; or demonstrating something to the class. I also noted the way that faculty members engaged in dialogue with students, and whether their discussions sought to: build rapport with students; ask a content/factual recall question; ask a higher-level question; offer feedback to students; ask a rhetorical question; or respond to students. I took note of the time faculty members spent on each of these tasks throughout the course of the class period, as well as on the ratio between teacher-focused activities compared to student-focused activities.

To look at the question of the effects of the physical layout of the classroom and the effects it might have on pedagogy, I observed how the layout was structured throughout the semester (i.e., desks that were mobile or in rows bolted to the floor; or desks that faced other students or were oriented to face the front of the classroom). I took note of how the physical layout of the classroom, as well as the number of students affected the type of teaching professors engaged in (i.e., lecture, group-work, or discussions), as well as how professors split students into groups.

To address the question of how professors structured the interactions in the classroom to create the classroom culture, I took note of the frequency of whole class discussions, and the frequency of students in peer groups teaching their classmates material. Additionally, of note, were the ways professors intentionally structured groups when students were split into smaller groups (or if they did not, and simply instructed students to pair up with another student), and whether or not there was attention paid to the gender and race distribution of groups.

To look at the question of how professors emphasize information in lectures and assessments of students' competence, I observed their pedagogical strategies surrounding assigned work to students. From research about the importance of the social relevance (connections to "real-life") of science to students (Archer et al. 2015; Badri et al. 2016; Bennett and Hogarth 2009; Lavonen and Laaksonen 2009), I took note of the pedagogical strategies professors used to tie the class material back to some "real-life" application, or specific connections to other disciplines, and ways this might have been achieved through exams, assessments, and other assignments.

During lectures I took note of concrete applications, often in the form of science videos, field trips, or guest speakers (and making note when that guest speaker was a woman scientist or a non-white scientist). I noted the extent to which professors had discussions of science career stages; the benefits of becoming a scientist; calling out and discussing the under-representation of women (and especially if there were historical discussions of the discipline); currently relevant science topics; ethics related to doing science; and attempts by the teacher to relate to the students' science experiences/stories. These discussions between professors and students were especially important to understanding how professors emphasized all students' ability to succeed in STEM, and their ability to make the course material socially relevant for students.

I also took note of how the professor assessed students' knowledge (i.e., tests and quizzes, homework, in-class activities, labs, or other assignments). I noted the frequency of tests or quizzes, homework, in-class assignments, and included the types of questions on these assessments (i.e., essays or multiple choice). The frequency and types of assessment helped me to assess the priorities of the professor in terms of student memorization (memorizing jargon and definitions) or more process-oriented questions (why cells behaved in a certain way; or why a line of code was creating an error) requiring a greater depth of knowledge from students.

While I had access to in-class worksheets that were handed around, I did not have access to the tests and quizzes (the professors wanted to control access to prevent stray exams from ending up in students' hands, which was especially important given that the same exam was used for all sections of the introductory courses for biology and computer science). However, when professors reviewed tests and quizzes with the class after they had been handed back, I took note of the components, such as test problems: requiring calculations compared to simple solutions solvable without math; involving data analysis; necessitating long written responses; drawing from the homework; considering material presented earlier in the semester; requiring sketching; requiring memorization; and simple multiple-choice or true–false. For other assignments I also differentiated between in-class or homework problems requiring group work, long written explanations, calculations, or multiple choice, as well as the frequency of these assignments.

To look at how professors structured the classroom material to help students acclimate to the expectations of disciplinary culture I noted when professors took time to professionalize their students during class sessions, in office hours, or via Learning Management Software (LMS) communications. The university where these classes took place has a subscription to the Canvas learning management platform, so all students had access to Canvas through the school. In addition to the Canvas software, the computer science courses primarily utilized an online forum service called "Piazza" that connected all students across the three introduction sections via a common discussion board. I had access to publicly posted comments and questions on the LMS used by students and faculty and was able to gather student feedback in this way.

Data Collection Tools

I utilized initial data from observations in each course to develop codes that guided additional data collection utilizing the Generalized Observation Research Protocol (GORP) program developed by the University of California, Davis. GORP is a web-based system to assist with classroom observations that utilizes user-defined protocols, and allows observers to record data using the GORP interface. GORP enabled me to measure the amount, and type of learning activities in classes by using a count system that reset in two-minute intervals. Over these two minutes I clicked codes that corresponded to the active tasks occurring in the classroom, allowing me to get a count of the number of times activities or pedagogical strategies occurred, as well as the length of time that they occurred each class period. The system also allowed me to take time-stamped qualitative notes of anything else that was happening in those two minutes, or to add detail to the quantitative counts. I took qualitative notes during every two-minute interval. GORP allowed me to create a summary of counts and frequencies (as a ratio of total class time) of classroom behavior and the participation of professors and students and other key behaviors in the classroom, such as lecturing, students asking questions, assessment activities in the classroom (tests and quizzes), and group vs. individual work (Hazari et al. 2013).

To observe the classroom climate and the classroom behaviors and activities that might lead to greater inclusion or exclusion, I developed a specific protocol with classroom activities and pedagogical strategies drawing from an existing protocol developed by the University of Colorado, Boulder (Office of Information Technology 2019). The University of Colorado, Boulder Observation Protocol for Learning Environments (OPLE) includes measures of teacher focused instruction and student focused instruction, with additional measures of teacher-led dialogue vs. student-led dialogue, along with the instructional technology and pedagogical strategies utilized by the teacher. I adapted this protocol (see Figure 1.1) to add additional measures from Hazari et al. (2010) on student engagement, as well as measures to record students' arrival and departure from the classroom, the TA behavior (assisting the professor, or on their cell phone), and to track the gender of the student responding to either student-led or teacher-led dialogue.

[Figure 1.1 about here]

Analysis

The present study drew on Charmaz (2005), as an updated iteration of (Glaser and Strauss' (1967) “grounded theory,” to systematically analyze my field notes and guide the creation of initial codes.

I utilized GORP to assist with ethnographic observations, looking “for explicit themes” while observing classroom conduct and treating what I see as objective (Charmaz 2002: 677). I utilized GORP to make additional observations of activities in classes, and to aid in recording the events of the class in a systematic manner, while additionally relying on my qualitative notes, and jottings that were used to construct a full set of field notes and memos for each class session.

At the end of each class (if time allowed), I would elaborate on my notes before the next class began, and made notes to myself of sections or examples that needed to be further elaborated later. At the end of each day of observations I took all of my notes and constructed a full set of field notes, drawing from the qualitative notes I recorded in the GORP system, along with additional notes and jottings I took in a notepad on the computer. Every week I wrote a brief, one-page memo of my broader observations, thoughts, and questions about my observations from that week. At the end of the semester I used GORP to create a summary chart (See Figure 1.2) of the sum total codes represented in the classroom. I used the frequency of these codes to guide my deeper line-by-line analysis of my field notes, and to develop additional codes in my memos drawing from my observation data in addition to the codes I had already developed for the GORP protocol.

[Figure 1.2 about here]

I also utilized abductive analysis (Tavory and Timmermans 2014) to guide further data collection and data analysis in the process of developing a theoretical framework. Abductive analysis builds on grounded theory's emphasis on simultaneous collection and analysis of data throughout the research process while utilizing knowledge and theories to ask new questions or see the world differently (Tavory and Timmermans 2014). By studying and analyzing data at the same time, researchers are able to find emergent ideas in the data (Charmaz 2005) and then to build on this by revisiting the data to take advantage of the ways the same observation changes when perceived at different points in time. GORP was especially helpful for this, by allowing me to break my summary data up to observe how each code was displayed in an individual class period, as well as throughout the course of the semester (Tavory and Timmermans 2014).

Findings

This study seeks to expand discussions about the classroom climate to specify concrete ways faculty members can deliberately contribute to building a class environment to create greater inclusion and minimize exclusion for students. As such, professor decision-making is at the core of classroom climate. But, this overarching research question subsumes more specific questions regarding elements of classroom climates experienced by students: the influence of the physical layout of the classroom, especially as it shapes interactions between professors, students, and their peers; professors' behaviors, pedagogical strategies, information emphasis, and means of assessment; and professors' positionality and conveyance of disciplinary culture. I discuss how my findings help to illuminate the factors that shape the classroom climate. Based on where courses land in terms of these factors, the patterns that emerge show how classes can have elements of both a hospitable and chilly climate. Courses are not just chilly vs. not chilly, or hospitable vs. not hospitable, but involve a myriad of factors representing each dimension. While a chilly climate may push students out, a hospitable one may help to keep them in the field. Yet, no class might be fully chilly or fully hospitable.

I describe here my observations of the biology and computer science courses. These classes are not perfect, and students indicate problems through their posts on the LMS. Nonetheless, these classes can serve as guides along the dimensions of chilly and hospitable practices that can help to make the field more inclusive. I organize my findings below by research question, discussing the impacts of class size, the physical classroom design, professor pedagogy, exams and assessments, and learning management software.

Institutional Power and Professor Decision Making

Faculty members to some extent have the ability to influence the classroom climate. Professors determine how much class time is allotted to lecturing, which was the class activity that occurred the most frequently in the classroom, coded 373 times over the course of my data collection, compared to group work which was coded less than 150 times (shown in Figure 1.2). The faculty member determined the frequency and time spent on lecturing and group work, as well as on formal and informal assessments. Based on whether a professor assumed students had advance knowledge of class material (whether from a previous high school course, or taking something to be assumed general knowledge) determined the amount of time spent on the topic, and how professors responded to student questions.

Professor's assumptions about students' previous knowledge indicated whether a professor reacted as though a student did not remember information they had previously known, or whether a professor taught materials quickly or slowly.

> In one of the biology classes the professor was rapidly moving through the slides, spending less than 30 seconds on each one. After about a minute, students are laughing because professor is going through the material really fast. He acknowledges this laughter, and addresses it, tells students he knows he is going fast, but that the notes will be posted. He wants to give a general overview.

The professor wanted to cover a lot of material, but acknowledged that many students may not have engaged with that material before, and would benefit from a general overview. However, this assumed students who had not previously engaged with the material would be able to master it at such a quick pace. Additionally, assumptions showed differences in how professors asked questions to students. For example, whether a professor who asked a question and received no responses assumed students had not been listening and re-stated the same question, or whether faculty members recognized students may be confused and re-phrased the question as a check on understanding:

> Biology professor at the board asking students how to label cells. A few responses. He asks, "Why that material?" Someone responds. Professor elaborates a little, but doesn't repeat student answers, making it difficult to follow along as students are far away and quiet. Professor asks about radioactive thiamine and answers without pausing for student

> responses. Elaborates about random selection of cells in the S phase. Begins talking, then notices a question from a woman in the section on the right. She asks a clarifying question, and professor responds, “You should have all drawn this plot as well as you can….” describes what it should look like and what to look for. Asks what else they think may have happened. Pause. Then a man responds, “cytokinesis.” “Exactly! I hope you are all plotting this at the same time…” professor draws and adds to graph. “Tell me everything that needs to happen here….?” Professor lists off the cell phases, and asks students. Pauses, no audible responses I can hear, but professor says, “I think you are right, there is a gap, but….” Continues to describe, and instructs, “you should also be doing this on your whiteboards. We also have to have a way to prove cytokinesis. So now we have to come up with another plot…” Professor asks a question. Asian man in the middle section answers and professor responds, “Yes, you are saying almost exactly what I want to hear, so I am going to rephrase it….” He rephrases the answer and explains.

In this example, the professor makes a few assumptions that: students in the back will be able to hear answers students in the front make; students will not know about radioactive thiamine; students are not following along and drawing on their whiteboards; and that students will not be able to draw out the correct information from a students’ answer to his question. By assuming students in the back were able to hear answers, from the back of the room I (and potentially other students as well) was not able to follow along with the discussion from the back of the classroom. In addition, the assumptions (which were not verified by the professor with the students) about students’ preparation, led to the focus of the discussion on how the cell phases worked.

Both biology and computer science involve challenges with learning new jargon and language. For biology this jargon involves things such as learning Latin and Greek roots and terms that are used to describe different cellular and molecular processes. Biology requires a new set of technical skills in terms of how to think about cells and molecules that are so small they cannot be seen by the human eye unaided—as a result, this requires new ways of thinking about how very small things interact together to result in complex processes that result in metabolic reactions or living things (why do cells need ATP, how do metabolic reactions work and why are they important?).

Computer science, on the other hand requires a slightly larger cognitive leap to learn a new language (in the case of the courses I observed, this was Java). An added difficulty for minority students who are more likely to come from underfunded school districts is the additional cognitive leap of learning a new way of thinking and setting up their thoughts and ideas in a very linear and logical way. For example, this can include minority groups or first generation college students who are on average less prepared for college, or who may have attended more poorly funded previous educational institutions (Hilts et al. 2018). For many students who have not had previous introduction to computer programing, writing code requires restructuring how to think about what it is they are trying to solve and how to get there (for example, object-oriented programing is object based, it's not uncommon to design things based on real-world objects. However, a problem to design something like a smart home system is difficult for a beginner to computer programing as they need to learn systematic ways to break a large problem down into subcomponents irrespective of the larger system to write the code).

In terms of the classroom climate, the extent to which professors in each field recognized the assumptions they were making about the knowledge of the students, and their preparation for the course influenced how they taught. For example, professors who assume students will not take additional classes within the discipline, may not spend as much time explaining more advanced concepts, and may instead focus on covering basic concepts based on possible assumptions based on stereotypes about students' future trajectories into the labor market (Gay 2018; Lee and Zhou 2015).

Institutional Factors of Class Size and Classroom Physical Layout

There were elements of the classroom structures in which professors taught outside of their and students' control that influenced the interactions between students and their peers and the professor. Larger classrooms are required for classes with 80 or more students, which creates a much more challenging and chilly environment to engage in multiple one-on-one conversations (noise and being able to hear each other). During a lecture it is impossible for all 80+ students to respond to professor's questions, speak up and engage in thoughtful discussion in the same 50-minute class period. I discuss the challenges associated with class size and physical classroom design and layout, and the implications this has on professor's pedagogical practices.

Class Size. Both biology and computer science classes took place in large classrooms and had around 80 students or more in each class. As mentioned previously, introductory courses tend to be large both in terms of the number of students, and the size of the classroom, and frequently involve the same classroom being used for multiple sections of the same course:

> The biology classroom is dark with only a few lights on, and it is set up in a typical lecture style, with theater style seats that have a very small "table" that can be pulled up or left down for space to put a laptop or notebook. Many students have laptops out and are clicking on screens while chatting quietly with classmates. By the time class starts at 11am almost all seats are taken by the almost 80 students except the back two rows, which is where I sit to have the best view of the entire classroom. Most students are clustered towards the front. The professor begins an activity with whiteboards, and there is brief chaos as students take whiteboards from the Teaching Assistants (TAs) and pass them down their rows and try to form small groups of three within their restricted seating.

Students had to talk very loudly to be able to hear each other over the discussions of the other groups closely clustered around them. The limited available seating in the room made it impossible for students to spread out or to have more space for their computers and the white boards. In addition, large class sizes limit students' abilities to talk with, or to get to know everyone in the class, including the professor, contributing to a more chilly climate and a less hospitable climate. In an effort to create a more hospitable climate, professors often attempted to overcome the depersonalization of large classes by organizing small group work to give students the opportunity to get to know at least a few other students in the class. However, as discussed in the next section, the success of these smaller groups was strongly impacted by the physical classroom layout in addition to the formation of these groups.

Physical Classroom Design. The physical layout of the classroom allowed for or restricted the ability for students and the professor or TAs to interact with each other:

> The computer science classroom during the 2:30-4 section is huge, and resembles a large lecture hall with very steep seating tiers that somewhat makes it look like a dungeon with the very small windows by the ceiling on the right side. The room has long rows of tables and bolted chairs set up in three sections with stairs separating the smaller wall sections of three chairs from the longer middle section with twelve to fourteen chairs in each row. Students are very sparsely seated around the room, with small clustered groups seated away from others.

All the biology courses and one computer science section occurred in a typical lecture hall, with immovable desks and seating that made small groups of three or more challenging, especially with other groups and students talking and working all around these groups, contributing to a more chilly climate and a less hospitable climate. Students were not very collaborative when given group work in the computer science lecture hall classroom:

> In the computer science lecture hall students are learning about fractal trees. Professor instructs students to pair up with neighbors and play around with variables to see what trees they produce with their code. Students do not move from their seats and only a few students begin talking to each other. Seated in the back of the room I can see almost a third of students on their phones, on Facebook, or with a blank computer screen and they are not doing anything at all. A student in front of me is reading an article on his computer and texting. Students are highly disengaged, and only few students are downloading the code and working alone.

In the lecture-hall section students would rarely move or adjust their seating to work with other students, and as a result would often work on assignments and tasks alone, despite the professor’s suggestion to work in groups. Looking at this quantitatively, students spent less than a minute on their group work for fractal trees in the lecture-hall section (see Figure 1.3).

[Figure 1.3 about here]

The two late afternoon sections of computer science took place in a large classroom with 12 large moveable round whiteboard tables and chairs. In addition, this “round-table” room had two projector screens in the front of the room as well as one each on the sides of the room. Faculty members from computer science as well as other STEM disciplines mentioned to me many times that this classroom was highly in demand for all STEM classes as a result of its easy collaborative space. It is likely the late time of these introductory courses (4-5:20 and 5:30-7) allowed for the use of this classroom. The introduction computer science professor also encouraged students to attend whichever section of the course worked for their schedules for the lecture, regardless of the section in which they were enrolled. By the middle of the semester there were only about 40 (out of 80) students attending the earlier lecture hall section, and this further contributed to students not working together in the lecture hall, students had space to spread out around the room and avoided sitting closely by their classmates, contributing to a more chilly climate and a less hospitable climate.

In contrast, attendance in the two later sections increased, so that this classroom went from having many empty seats at the tables to almost every seat being taken. Students sat in much closer proximity to one another which made collaboration and seeing each other’s screens and discussing much easier:

> Professor has three activities for students, he instructs them to work on the first one together, then work on the next two on their own. First method called insert and takes four parameters. “Where is the catch? The catch is that I want to insert in the array and move all of the other numbers one position forward.” Woman at my table turns around from looking at the projector screen to look at other students at the table and asks, “Where to start from?” Scattered responses around the table, and I can hear lots of discussion from the front of the room and at other tables. Lots of collaborative responses. A man and woman at my table are talking about the logic and theory of what they need to do. Man then says, “Okay, let’s do it in code.” Describes what we need to do. “We can use a loop, what type of loop do we want to use?” Responses from around the table, and

> students are looking at the code on each other's screens. Another question. "What is the condition that keeps us inside the loop?" Scattered responses from students at the table, and I hear the continued discussion from students at other tables….Professor calls students to move on to the next activity, "Okay guys, to see if you really understood, try to solve, no, not try, solve the next one. Instead of inserting, I want you to remove the element from the array." Explains in more detail what he wants them to do. "Clear? Alright get to work! 7-8 minutes and then we will solve together." Students continue to work together and all students at my table are collaborating. "What do you call a blank? An empty cell in an array?" Man next to me asks and collaborates with woman next to him. "Running it, running it! Oh….won't compile!" man next to me complains and several other students turn towards us and offer advice and suggestions.

Students working on the same problems and tasks as the lecture hall section were much more collaborative on problems and tasks, even working together on problems when instructed to work through parts on their own (and they were not sanctioned by the professor for doing it), contributing a more hospitable climate and a less chilly environment. Comparing the above example of the fractal-tree group activity, students in this more collaborative space worked in groups for 20-minutes, compared to the less than a minute in the lecture-hall class (see Figure 1.4). Additionally, in the middle of the semester I recognized a few students attending the later sections who earlier in the semester had been in the lecture hall section. Many of these students worked alone in the lecture-hall section, but when attending the later sections were drawn in by other students to work collaboratively.

[Figure 1.4 about here]

While it was more physically challenging for the students sitting in an immoveable row to all talk to one another, especially in larger groups, the computer science and biology professors attempted to overcome the setup and to encourage students to group together to discuss things. That is, professors tried to adjust their pedagogy and encouragement of group work as a response to the more chilly climate created by the physical layout, to create a more hospitable climate. However, overcoming the challenges created by the physical layout to group work required more than just telling students to work as a group, as I detail subsequently.

Pedagogical Practices of Professors

Pedagogy: Role of accountability. In their teaching, professors made decisions on how to encourage collaboration and group work among students. While the lecture-hall physical layout discouraged students from working together and collaborating, the biology professors were able to overcome this challenge by requiring students to be accountable with formal and informal assessments of the work they needed to complete as a group. Initial research into accountability in STEM courses discusses accountability as a “social practice” that shapes the actions and behaviors of group members when they are held responsible for accomplishing something (Hallett 2007; Teo and Osborne 2014). In the biology classes professors worked to overcome the spatial layout to encourage interactions among students to create a more hospitable climate and less chilly climate by both formally and informally assessing small group work. The department purchased whiteboards and markers for groups to write or draw responses that were then shared with the class by holding up group white boards and giving brief explanations. These white boards allowed for a more informal assessment of student work, and ensured students had a low-stakes deliverable to motivate them to stay on-task. In addition, on Fridays, students had a more formal assessment of their group work in the form of worksheets (or quizzes) they had to complete for a grade as a group. During a lecture on glycolysis, one of the biology professors had students work in groups on their white boards before coming together as a class to answer questions about the process (see Figure 1.5). Students spent the first 15 minutes of class working in groups and then remained high to moderately engaged for the remainder of the class. Both the low-stakes deliverables and the graded quizzes required the students to work together and actually collaborate to avoid sanctions (publicly by not having anything to share, or a low grade on their quiz). This pedagogical strategy contributed to improving biology's hospitable climate and reducing the chilly climate.

[Figure 1.5 about here]

By contrast, in the computer science classes, while the students were encouraged to participate and write code for the in-class assignments in small groups, there was no deliverable either informal or formal to show that they had, or had not attempted to write the code. As a result, students were not held accountable to complete the work—either individually, or as a part of a group, in the computer science lecture hall section. One result of this was that students rarely, if ever collaborated or worked together, despite being instructed to do so, contributing to a higher chilly climate, and a lower hospitable climate. However, as mentioned previously, students formed groups organically even without being instructed to do so, and worked together in the late afternoon sections in the round-table classroom—students talked through the activities together, even without any check they had actually completed the work. My findings in biology suggest that to overcome the physical constraints of the lecture-hall classroom, and to encourage the formation of groups and a more hospitable climate, students need to be motivated by professors requiring them to be accountable through some deliverable. In fact, requiring students to actively participate, with peers, and perhaps with the class may have been a way to increase the participation of women and URMs in the classroom.

Emphasis of Assessments of Competence and Information

Large class sizes for both biology and computer science and packed classrooms made decisions about how to structure exams much more complicated. With around 80 students per section, and multiple sections biology and computer science faculty members did not generally have the resources to grade long papers, essay exams, or intensive assignments. Faculty members had varying strategies to handle exams and formal assessments of students over the course of the semester. For example, in biology the professor utilized exams as an opportunity to help students work together:

> Professor hands out copies of the multiple-choice exam for students to take together in groups of 2-3 to create their team key, then they come together as a class to discuss their answers. Students get into groups and re-take the exam…. At 11:25 they begin going over the exam, talking through each answer, and stopping to discuss questions where there are disagreements. For example, two Asian men have a complex grammatical question about one of the questions. Students are laughing and mocking this student, especially as one becomes increasingly agitated trying to explain how his answer is correct based on the grammar change. A black man in the class offers support for the student and when questioned about it by other students he says, "no, I'm just trying to back my man up." Students are laughing. Confusion is resolved and professor moves on to the next question.

It would have been impossible for the professor to have one-on-one discussions with 80 students about their exam, so instead, the professor used an entire class period to help students understand the material, both by working in groups to take the exam for a second time, and to have the opportunity to discuss any confusions or questions they had about a particular right or wrong answer. By going over every answer the professor ensured that students understood the importance of all the material that was on the exam, rather than just going over questions that a student requested discussion on, contributing to a more hospitable climate.

In addition, the biology professors structured exams and preparation for exams concretely, by telling students, "The first exam helps you to know what to expect the rest of the semester. These concepts will be taught over and over to various extents and degrees because it's important for the future material." The professors emphasized the extent to which students needed to understand concepts from chemistry, and how this material was related to the biological concepts they were learning as well.

In comparison, in computer science department students would complete a written and lab portion of the tests, and the test was not discussed during class time. As a result, the test was not really discussed with the class as a whole, and did not offer the same sort of opportunity for students to discuss and talk about any questions or concerns that they had about the exam. This put the expectation on students to have conversations with the professor or the TA on a more individual basis, which can be more difficult for students with less “science” capital (Archer et al. 2015). Expectations that students should come in to discuss their exam questions individually assumes that only the minority of students struggled on the exam, and that the entire class would not benefit from a discussion of the exam material contributing to a less hospitable climate and a more chilly climate.

Emphases on more basic materials can create a chilly classroom climate by implying that students are not smart enough to master advanced concepts. Navigating the transition to college is especially challenging for students whose previous schooling may not have been as effective in helping them to learn how to recognize and focus on the “low-level” information they need to understand and master to move on to more complex “high-level” information. Professors who take the time to check their assumptions with students about their level of understanding, and then provide the necessary resources to address it, create a more hospitable climate that signals to students that the professor aims to help everyone succeed.

Students often stressed about their ability to perform well on exams and sought resources to help them study for exams. In addition to providing a study guide the biology class had fun extra credit opportunities for students to help them connect to the material, and to create resources that can be used to help students in future classes:

> Professor talks about an extra credit opportunity on the next exam. On Monday (Halloween), they can come to class in a biologically relevant costume of some kind, home-made and represents something they have talked about or will this semester. He says, “However you want to be, just be creative with it. You can’t just come to class with a piece of paper taped to shirt that says ‘ATP’”. Students laugh and he explains that they

> need to bring in a write-up of what their costume is, and why it is important in the function of life.

The professor then used the previous year's materials as examples for current students. This activity helped to connect students to past students from the course, as well as to help them think creatively about connecting on a deeper level with the course material in a fun way. During the class on Halloween, students had a brief "show" where they were able to show off and discuss their costumes with the class. The show allowed students to visualize and see the class materials in a new way, and required presenters to have thought about a creative way to visually show and display course concepts, contributing to a more hospitable climate. In addition, the biology professors prepared students by reminding them that, "There will be a LOT of information, the best way to get it, is to study it now, start now." Professors emphasized the importance of not waiting until the last minute to try to memorize the vocabulary terms, and the importance of using previous knowledge to build up to more advanced concepts, "And yes, you need to know *all* of these vocabulary words. You *gotta* get comfortable with seeing how these terms are related to each other." This preparation attempted to help students acclimate to the nature of science learning at the higher education level, which relied on learning scientific jargon, and not only memorizing what terms were, but understanding how they related to each other more globally.

While the computer science department did not have a specific activity to help share resources from past students, the Piazza site served as an informal repository of shared resources from previous classes. Piazza enabled students to utilize materials and discussions that were archived from the previous year, and to search through previous students' questions and discussions about class activities and assignments. The computer science professor also posted weekly sample questions (to help students prepare for their lab quizzes) to give students examples of typical quiz and test questions. Students were thus provided with resources and materials to help them succeed, contributing to a more hospitable climate.

An additional concern for students related to performing well was how assessments were graded. Grading was not a specific source of contention in the biology department, as the professor completed all the grading. The TAs assisted with handing out and collecting the group quizzes during class. In comparison, there was more contention over grading in the computer science department as the TAs did most of the grading in addition to peer graded assignments. Students did not have access to any kind of standardized rubric being used by the TAs, and students complained on Piazza and in class about the lack of feedback on the assignments from the TAs, "A lot of the TAs have not been giving sufficient justification for taking points off. It is very difficult to understand the vague comments that are left. Can the TAs leave better comments and justifications for taking points off on quizzes?"

In addition, students discussed the peer evaluations on Piazza:

> I'm concerned about the grades for the peer evals. I've spoken to TA's [sic] about my grading decisions and they agree with my logic, then I submit the score only to find that people are consistently rating the grade as [too high]. I'm left to believe that people aren't reading the code as carefully as I am and are missing these mistakes, giving me a lower score than I feel is fair. How will this be addressed?

The more “anonymous” styles of grading in the computer science classes, in other words, not knowing specifically which TA, or which students were grading or evaluating their materials was a source of frustration for the students, and contributed to a more chilly climate and less hospitable climate. The computer science students did not have a specific person that they could pinpoint as responsible when they perceived an error in their grading, and as such they did not know how to address their concerns. The issue of grading was also likely compounded by the individual nature of handling discussions about the assessments (i.e., discussing the exam as a class, or only during office hours). Students had issues with the grading that they wanted addressed, but experienced uncertainty in how to resolve the issues with their evaluator. Students who don't have the science capital (Archer et al. 2015) necessary to help them talk to the professor to resolve their uncertainty and discontent with their grades are likely to experience a more chilly classroom climate, while clearer grading criteria, perhaps through a rubric signals a more hospitable climate.

Pedagogy: Social relevance. Professors who were able to find ways to make the class material socially relevant for students succeeded much more in drawing students in, and keeping students engaged, which positively impacted the classroom culture. The more involved and engaged students were with the material, the more likely it was that they would respond to questions posed to the class, and draw in other students. The biology courses made frequent and direct references to real-life applications of the material. For example, during a lecture in the cancer unit, the biology professor solicited examples from students of types of cancer they had experience with through friends or family, and then discussed these types of cancer and the ways the cells worked differently in the different types of cancer to help make the material more personal for the students. Despite the 50-minute class being mostly lecturing (36:13 minutes), students were moderately or highly engaged throughout that time (see Figure 1.6). The biology professor chose specific examples to which students could relate without any previous formal knowledge to engage as many students with the material as possible, contributing to a more hospitable climate and less chilly climate.

[Figure 1.6 about here]

Similar patterns did not emerge for the computer science department, and I did not have specific notes about direct real-life connections of the materials. However, some of the more engaging activities students participated in included group assignments for students to write computer code that simulated ordering pizza in an online system (see Figure 1.7), locating a bank account in a server, and writing code to catalogue and organize an address book that received new entries. Figure 1.8 shows students spent the last hour of class engaged in groups writing code to order pizza, and spent the entirety of this time highly to moderately engaged while doing this work, thus while it contributed slightly to a more hospitable climate, it did not really reduce the chilly climate.

[Figure 1.7 about here]

Disciplinary Practices and Science Capital

Learning Management Software. An important aspect of course structure and how students and faculty interacted was the inclusion of technology or software to aid in student learning. In addition, the use of an LMS signals an openness to discussion and student engagement. The computer science department attempted to use Piazza to create a hospitable, collaborative environment for students. Students regularly engaged with Piazza as a site where the professor posted practice quizzes, and practice homework assignments, to check course announcements from the professor (or TAs about office hour changes), and students regularly engaged with each other on the site. Students could ask and answer each other's questions, and often sought feedback and help from their around 250 peers on creating and writing segments of their code with the option to seek additional guidance from TAs or the faculty member.

Of particular note, the computer science department has a history of honor code violations surrounding students' plagiarized use and copying of peer's code, whether from previous or current students taking the class. Students received multiple announcements from the professor on "serious academic integrity violations" during quizzes, labs and homework assignments, such as the following:

> I found evidence that some students executed the code that was supposed to be manually traced during quizzes. Let me remind you once again (see post @212) that this is a serious violation of academic integrity and it will not be tolerated.
> 1) The scores of affected questions will be revised and lowered.
> 2) The Honor Council will be notified.
> 3) It may take a few weeks to complete tasks (1) and (2), so do not assume that I haven't caught you if you don't see any consequence right away.
> 4) Cheating is wrong and it negatively affects the entire class: all the time that I need to waste collecting evidence, revising scores, and writing reports to the Honor Council is time that I would rather spend helping individual students and preparing better learning resources for all of you. Moreover, if the average scores of certain questions are artificially inflated by cheating, I may wrongly assume that those questions were "too easy" and make them harder next time, effectively damaging the students who don't cheat.
> 5) There are no excuses or special circumstances to justify cheating. I need to be strict about it. I want my course to be an effective learning environment, and to be as fair as possible to all the students.

As a result of past issues with plagiarism and students’ code, assignments and exams were under high levels of scrutiny to ensure students were submitting their own work. Due to the high levels of scrutiny and plagiarism risks within computer science for sharing code directly, students regularly took the time to discuss and explain the logic behind their coding decisions when answering questions for other students in Piazza. In other words, students focused more on explaining the processes and logic behind the problems and the resulting code, rather than answering with a specific line of code that would solve an error that students might encounter. This resulted in Piazza allowing students to seek individualized help and answers to their questions that did not rely solely on the professor and TAs to constantly be involved. In many cases, this allowed for students to search for the answer to a question they had which had already been answered by another student, a TA, or the professor. Piazza also helped students organize study or working groups, and was easily accessible and open to all students across sections, contributing to a more hospitable climate.

In comparison, the biology department was not as clearly engaged in using their LMS to promote open discussions and student engagement. The biology classes relied solely on Canvas, and the professors tried to encourage use of the discussion boards on Canvas without success. Students did not invest in using Canvas for anything besides checking their grades, or getting access to posted PowerPoint slides or materials. Students discussed using GroupMe, a chat program to create study groups that seemed to be more successful than using their course created Canvas site. However, this was never explicitly talked about, advertised, or utilized by the faculty members or TAs to ensure all students had access to this chat group or the materials shared there, thus not really contributing to a chilly or hospitable climate. In order for these sites to be useful and inclusive to all students, it is important to ensure active investment and engagement by the students, and for there to be ways for all students to have access to create a hospitable climate.

Disciplinary practices. In addition to the class size and physical-layout of the classroom, additional structural elements of the department and university influenced the pedagogy of the computer science and biology professors—specifically, the presence or absence of groups and organizations to support and socialize underrepresented groups in STEM. This variation in programming and organizations created differences in the open discussion of resources available to students to work on their professionalization and to gain “science capital” (Archer et al. 2015) both in the classroom and outside of it.

During the course of several classes in biology the faculty members mentioned and talked about two different programs at the university that supported the education and mentoring of students from diverse backgrounds. One of these programs, an NIH funded program for improving student development specifically focused on minorities in the biological sciences sponsors students to receive in-depth experiences in the academic and experimental aspects of biological research in labs on projects. The NIH program sponsored extra workshops and science-related activities that underrepresented students could participate in to receive extra mentoring and advising, and additional social programs for students to build connections with other students. This allowed the biology professors to mention and talk about the successes of previous minority students, and to discuss events and talks being organized by these students around campus.

In addition, the diversity of the students in the classroom was specifically highlighted and discussed in the classroom, especially in relation to the NIH program. This type of open discussion about the diversity of the students helped to highlight for students that the department valued them and had resources dedicated to supporting them during their undergraduate careers, contributing to a more hospitable climate, and a less chilly climate. In fact, this may be part of the reason why women participated much more equally in biology (and in fact more than men) compared to computer science (see Figure 1.8).

[Figure 8 about here]

Such patterns did not emerge in what I observed for computer science. There were no similar programs or opportunities for the computer science course that I was aware of either from information told to the students in the class, via email, or Piazza. The computer science professor did not engage in any sort of open discussion about mentoring or socialization during the class period in front of all of the students, contributing to a chillier climate, in which women did not participate equally.

Discussion

This study seeks to expand on the limited discussion of chilly climates to identify not only factors that push students out of STEM, but to also note the factors that pull students in. Overall, I argue classroom climate should be conceptualized as having two dimensions: chilliness and hospitableness, where elements of pedagogy and structure position classroom climate along these two axes (See Figure 1.9). I define the hospitable climate as one that draws students in, encourages engagement with the material, and creates a classroom environment where students feel safe and comfortable speaking up during class, without fear or intimidation from professors and peers. My findings above indicate how certain institutional and interactional classroom practices can be amplified to create a high hospitable and low chilly classroom climate. I emphasize the importance of professor decision making, institutional factors such as class sizes and the physical design of the classroom, as well as interactional factors such as pedagogy, exams and assessments, LMS, and the positionality of professors and disciplinary practices.

[Figure 1.9 about here]

Impact of Factors Beyond Faculty Control

Previous research highlights many factors outside of the control of faculty, such as the day and time the course is offered (Ammons 1995; Wile and Shouppe 2011), the size cap for enrollment (Schneider and Preckel 2017; Toth and Montagna 2002), the room the classroom is offered in and the physical layout of that space within the room (Han et al. 2018). These factors constrain the pedagogical choices that faculty members can make, and require greater flexibility in how to encourage and ensure successful group work and the grading of assignments and assessments.

My findings indicate that as class size increases, without any adjustment on the part of the faculty member, the chilly climate would increase (see Figure 1.2). My findings show that faculty members who are able to introduce both graded and ungraded deliverables for accountability from students are able to overcome some of the challenges involved in motivating students to work together as a group, especially in physically constrained spaces (which increase the chilly climate). For example, professors can utilize the flipped classroom approach, which tasks students to engage in events traditionally taken place inside the classroom outside of it (i.e., watching a lecture, or completing an equivalent reading) to allow for more class time to be spent on group or small group discussions (Bishop and Verleger 2013; Gilboy, Heinerichs, and Pazzaglia 2015; Jinlei, Ying, and Baohui 2012) or hands-on exercises (Hew and Lo 2018; Roehl, Reddy, and Shannon 2013). The flipped classroom approach may make it easier to help students work in groups and complete accountability assignments, as more class time can be dedicated to this work if students have completed the lecture materials before class, and thus contribute to a more hospitable climate.

Impact of Faculty Decision Making

Professors' decision making in designing the lectures and assessments contributes in many ways to the classroom culture and their emphasis (or lack thereof) of all students' ability to succeed in STEM. Faculty members who acknowledge the uneven starting points of all students, and use their positions to make students aware of readily available resources to aid in their success can contribute to a more hospitable classroom culture. Based on my observations, there are elements that can be introduced into the classroom to help students overcome the learning curve required for students to succeed in the course. Professors who are clear and transparent in their expectations for proficiency (especially by providing study guides or resources from past students for studying) can help students to transition successfully from high school STEM courses to college STEM courses. My results suggest that faculty efforts to provide students with professionalization opportunities and resources (such as emailing professors, setting up a meeting with professors, or how to ask for help) in the biology department may be helpful in guiding students on how to ask for assistance when they are struggling to overcome the learning curve can ensure students acquire the science capital (Archer et al. 2015) required to succeed in college.

Faculty members structure the interactions that occur between professors and students throughout the course. These interactions occur both physically within the classroom as well as online through the use of LMS. The use of LMS is particularly important for large introduction lecture courses, because it allows an additional medium for students to interact with their classmates in a less overwhelming and manageable way. The computer science department was able to encourage students to bring their questions about an assignment or assessment to Piazza, rather than to search on the internet for an easy answer or solution by utilizing a negative situation (honor code violations and plagiarism). This helped students to more readily rely on each other to explain and discuss problems they were experiencing in the course. However, only the computer science department was successful in utilizing the LMS in this capacity, for students to connect with students from other sections of the course, and to build relationships and collaborative experiences with even more classmates. The biology department had separate Canvas sites for each introductory course, and did not have a similar online resource to connect students across sections. Additionally, students did not utilize the discussion board in the biology classes at all. I argue that increased usage of an LMS where students are engaged can help to create an online community for students that will support a hospitable climate.

For exams and assessments, professors who provide students with materials and resources they need to succeed (such as study guides and practice questions) create a more hospitable climate. In addition, when faculty members make the grading of assignments clear and transparent, perhaps through a rubric, they help students to understand how to improve for future assignments. Doing so creates a more hospitable climate. As suggested by previous research, students may also be helped through guidance in how to recognize the difference between memorizing basic “lower-order” information (like vocabulary and jargon) and engaging in critical thinking required for “higher-order” mastery of material (Crowe et al. 2008). Professors can do this by providing study materials from previous students, as well as providing resources and discussions in class for how to study for an exam. The biology professors excelled at this, by reminding students about the importance of not just memorizing terms, but understanding how the terms were related to each other (and how cells and molecules work under different circumstances). The computer science professor in contrast did not explicitly discuss the process of making cognitive shifts to complete logical proofs for coding, or strategies for working out problems on exams. Future work which can investigate the effects of this intervention can determine its effectiveness in assisting students to learn how to manage their time and the college workload.

General Directions for Future Research

While this analysis has expanded on the previous literature focused on the chilly climate and ways to mitigate or limit the effects of the chilly climate, there are many avenues for future studies. Moving beyond the focus of this study at a private university in the Southeastern U.S., future research could include and compare STEM instruction in state universities as well as other large and small private institutions. Moreover, the breadth of STEM disciplines might be considered in future research. In addition, my study was limited by being able to only observe one faculty member's approach to instruction in the computer science department, and thus, it may be possible to compare the impact of characteristics of instructors on classroom practices (and whether women and URM professors create more hospitable climates).

Another potential area of future research is expanding typical areas of underrepresented groups in STEM in U.S. classrooms to include the language barriers for international students that impede their ability to connect with other students. Part of the answer to encouraging persistence in STEM appears to be through student engagement (Flynn 2016; Kuh 2003; Ohland et al. 2008), which I argue is related to the ways students interact in the classroom to form connections to professors and peers. Classrooms perceived to be hospitable to all types of students where faculty members structure the class to encourage students to connect with each other are more likely to help students form these connections to their peers.

My study broadens the discussion of classroom climates to argue for dimensions of chilly and hospitable teaching and educational practices that impact the ways students can connect with their courses and the material, their professors, peers, and their disciplines. Many organizational structure and culture studies in education compare across educational institutions and their effects on STEM persistence rates (Armstrong and Hamilton 2013; Margolis and Fisher 2002). I build on the chilly climate literature to contribute to the less researched influences of the micro-interactional level (the classroom-level) on creation of more hospitable classroom climates. Ideally as students experience classroom climates with classroom practices that are both chilly and hospitable, the more professors can amplify hospitable practices to help students to feel supported and engaged within their STEM courses, and minimize chilly practices to avoid pushing students out of STEM classes and departments. This paper has elaborated on the classroom dynamics that vary along the classroom climate spectrum to allow researchers to better understand not only what the lack of a chilly climate looks like, but the importance of specifying the active demonstration of welcoming practices to encourage women and URMs to persist within STEM. It is not only avoiding the chilly climate that matters to help students avoid being pushed out of STEM, but ensuring faculty members use their institutional power to engage in pedagogical strategies that actively engage students.

Works Cited

Allen, Jill, Jessi L. Smith, and Lynda B. Ransdell. 2019. “Missing or Seizing the Opportunity? The Effect of an Opportunity Hire on Job Offers to Science Faculty Candidates.” *Equality, Diversity and Inclusion: An International Journal* 38(2):16–177.

Ammons, T. Lorraine. 1995. *The effects of time of day on student attention and achievement*. Unpublished manuscript. Charlottesville: University of Virginia, Curry School of Education. (ERIC Document No. ED384592)

Anaya, Guadalupe and Darnell G. Cole. 2001. “Latina/o Student Achievement: Exploring the Influence of Student-Faculty Interactions on College Grades.” *Journal of College Student Development* 42(1):3–14.

Appel, Markus and Nicole Kronberger. 2012. “Stereotypes and the Achievement Gap: Stereotype Threat Prior to Test Taking.” *Educational Psychology Review* 24(4):609–35.

Archer, Louise, Emily Dawson, Jennifer DeWitt, Amy Seakins, and Billy Wong. 2015. “‘Science Capital’: A Conceptual, Methodological, and Empirical Argument for Extending Bourdieusian Notions of Capital beyond the Arts.” *Journal of Research in Science Teaching* 52(7):922–48.

Archer, Louise, Jennifer DeWitt, Jonathan Osborne, Justin Dillon, Beatrice Willis, and Billy Wong. 2010. “‘Doing’ Science versus ‘Being’ a Scientist: Examining 10/11-year-old Schoolchildren’s Constructions of Science through the Lens of Identity.” *Science Education* 94(4):617–39.

Archer, Louise, Jennifer DeWitt, and Beatrice Willis. 2014. “Adolescent Boys’ Science Aspirations: Masculinity, Capital, and Power.” *Journal of Research in Science Teaching* 51(1):1–30.

Armstrong, Elizabeth A. and Laura T. Hamilton. 2013. *Paying for the Party*. Cambridge, Massachusetts: Harvard University Press.

Aronson, Joshua, Geoffrey Cohen, and Wendy McColskey. 2009. "Reducing Stereotype Threat in Classrooms: A Review of Social-Psychological Intervention Studies on Improving the Achievement of Black Students. Issues & Answers. REL 2009-076." *Regional Educational Laboratory Southeast*.

Aronson, Joshua, Diane M. Quinn, and Steven J. Spencer. 1998. "Stereotype Threat and the Academic Underperformance of Minorities and Women." Pp. 83–103 in *Prejudice: The target's perspective*, edited by J. K. Swim and C. Stangor. Academic Press.

Astin, Alexander W. 1984. "Student Involvement: A Developmental Theory for Higher Education." *Journal of College Student Personnel* 25(4):297–308.

Badri, Masood, Ali Alnuaimi, Jihad Mohaidat, Asma Al Rashedi, Guang Yang, and Karima Al Mazroui. 2016. "My Science Class and Expected Career Choices—a Structural Equation Model of Determinants Involving Abu Dhabi High School Students." *International Journal of STEM Education* 3(1):12.

Basit, Tehmina N. 2012. *I've Never Known Someone like Me Go to University': Class, Ethnicity and Access to Higher Education*. edited by T. N. Basit and S. Tomlinson. Bristol: Policy Press.

Bennett, Judith and Sylvia Hogarth. 2009. "Would You Want to Talk to a Scientist at a Party? High School Students' Attitudes to School Science and to Science." *International Journal of Science Education* 31(14):1975–98.

Bishop, Jacob Lowell and Matthew A. Verleger. 2013. "The Flipped Classroom: A Survey of the Research." Pp. 1–18 in *ASEE national conference proceedings, Atlanta, GA*. Vol. 30.

Bloom, Benjamin Samuel. 1956. *Taxonomy of Educational Objectives: The Classification of*

Educational Goals. New York: Longmans Green.

Bourdieu, Pierre. 1977. *Outline of a Theory of Practice*. Vol. 16. edited by J. Goody. Cambridge, Massachusetts: Cambridge University Press.

Bystydzienski, Jill M. and Sharon R. Bird. 2006. *Removing Barriers: Women in Academic Science, Technology, Engineering, and Mathematics*. Bloomington: Indiana University Press.

Carter, Prudence L. 2012. *Stubborn Roots: Race, Culture, and Inequality in US and South African Schools*. Oxford: Oxford University Press.

Chang, Mitchell J., Jessica Sharkness, Sylvia Hurtado, and Christopher B. Newman. 2014. "What Matters in College for Retaining Aspiring Scientists and Engineers from Underrepresented Racial Groups." *Journal of Research in Science Teaching* 51(5):555–80.

Charmaz, Kathy. 2005. "Charmaz Grounded Theory in the 21st Century." Pp. 507–36 in *The SAGE Handbook of Qualitative Research*, edited by N. K. Denzin and Y. S. Lincoln. Thousand Oaks, California: Sage.

Chen, Xianglei. 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, Xianglei and Matthew Soldner. 2013. "STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report." *Report NCES 2014–001, US Dept. of Education*.

Cheryan, Sapna, Allison Master, and Andrew N. Meltzoff. 2015. "Cultural Stereotypes as Gatekeepers: Increasing Girls' Interest in Computer Science and Engineering by Diversifying Stereotypes." *Frontiers in Psychology* 6:49.

Cheryan, Sapna, Victoria C. Plaut, Caitlin Handron, and Lauren Hudson. 2013. "The Stereotypical Computer Scientist: Gendered Media Representations as a Barrier to Inclusion for Women." *Sex Roles* 69(1–2):58–71.

Cheryan, Sapna, Sianna A. Ziegler, Amanda K. Montoya, and Lily Jiang. 2017. "Why Are Some STEM Fields More Gender Balanced Than Others?" *Psychological Bulletin* 143(1):1–35.

Cotten, Shelia R. and Bonnie Wilson. 2006. "Student–Faculty Interactions: Dynamics and Determinants." *Higher Education* 51(4):487–519.

Crowe, Alison, Clarissa Dirks, and Mary Pat Wenderoth. 2008. "Biology in Bloom: Implementing Bloom's Taxonomy to Enhance Student Learning in Biology." *CBE—Life Sciences Education* 7(4):368–81.

Dika, Sandra L. 2012. "Relations with Faculty as Social Capital for College Students: Evidence from Puerto Rico." *Journal of College Student Development* 53(4):596–610.

Eagan, M. Kevin and Audrey J. Jaeger. 2008. "Closing the Gate: Part-time Faculty Instruction in Gatekeeper Courses and First-year Persistence." *New Directions for Teaching and Learning* 2008(115):39–53.

Eccles, Jacquelynne S., Carol Midgley, Allan Wigfield, Christy Miller Buchanan, David Reuman, Constance Flanagan, and Douglas Mac Iver. 1993. "Development during Adolescence: The Impact of Stage-Environment Fit on Young Adolescents' Experiences in Schools and in Families." *American Psychologist* 48(2):90.

Ewell, Peter T. and Dennis P. Jones. 1996. *Indicators of "Good Practice" in Undergraduate Education: A Handbook for Development and Implementation.* Boulder, CO: National Center for Higher Education Management Systems.

Flynn, Daniel T. 2016. "STEM Field Persistence: The Impact of Engagement on Postsecondary

STEM Persistence for Underrepresented Minority Students." *Journal of Educational Issues* 2(1):185–214.

Foster, T. J., M. S. Foster, K. Flaugh, J. Kinschner, and N. Pidcock. 1994. An Empirical Test of Hall and Sandler's 1982 Report: Who Finds the Classroom Climate Chilly? Available online: https://eric.ed.gov/?id=ED373368 (accessed on 17 May 2018).

Friedrich, Katherine A., Sherrill L. Sellers, and Judith N. Burstyn. 2008. "9: Thawing the Chilly Climate: Inclusive Teaching Resources for Science, Technology, Engineering, and Math." *To Improve the Academy* 26(1):133–41.

Froiland, John Mark, Frank C. Worrell, and Hyejeong Oh. 2019. "Teacher–Student Relationships, Psychological Need Satisfaction, and Happiness among Diverse Students." *Psychology in the Schools* 56(5):856–70.

Gainen, Joanne. 1995. "Barriers to Success in Quantitative Gatekeeper Courses." *New Directions for Teaching and Learning* 1995(61):5–14.

Gay, Geneva. 2018. *Culturally Responsive Teaching: Theory, Research, and Practice*. New York: Teachers College Press.

Gehlbach, Hunter, Maureen E. Brinkworth, Aaron M. King, Laura M. Hsu, Joseph McIntyre, and Todd Rogers. 2016. "Creating Birds of Similar Feathers: Leveraging Similarity to Improve Teacher–Student Relationships and Academic Achievement." *Journal of Educational Psychology* 108(3):342.

Gilboy, Mary Beth, Scott Heinerichs, and Gina Pazzaglia. 2015. "Enhancing Student Engagement Using the Flipped Classroom." *Journal of Nutrition Education and Behavior* 47(1):109–14.

Glaser, Barney and Anselm Strauss. 1967. *The Discovery of Grounded Theory*. Chicago: Aldine

Publishing Co.

Glass, Jennifer L., Sharon Sassler, Yael Levitte, and Katherine M. Michelmore. 2013. "What's so Special about STEM? A Comparison of Women's Retention in STEM and Professional Occupations." *Social Forces; a Scientific Medium of Social Study and Interpretation* 92(2):723.

Good, Catherine, Joshua Aronson, and Michael Inzlicht. 2003. "Improving Adolescents' Standardized Test Performance: An Intervention to Reduce the Effects of Stereotype Threat." *Journal of Applied Developmental Psychology* 24(6):645–62.

Haak, David C., Janneke HilleRisLambers, Emile Pitre, and Scott Freeman. 2011. "Increased Structure and Active Learning Reduce the Achievement Gap in Introductory Biology." *Science* 332(6034):1213–16.

Hall, Roberta M. and Bernice R. Sandler. 1982. "The Classroom Climate: A Chilly One for Women?" in *Project on the Status of Women*. Washington D.C.: Association of American Colleges and Universities.

Hall, Roberta M. and Bernice R. Sandler. 1984. "Out of the Classroom: A Chilly Campus Climate for Women?" Washington D.C.: American Association of American Colleges and Universities.

Hallett, Tim. 2007. "Between Deference and Distinction: Interaction Ritual Through Symbolic Power in an Educational Institution." *Social Psychology Quarterly* 70(2):148–71.

Han, Heesup, Kiattipoom Kiatkawsin, Wansoo Kim, and Ju Hea Hong. 2018. "Physical Classroom Environment and Student Satisfaction with Courses." *Assessment & Evaluation in Higher Education* 43(1):110.

Hartlep, Nicholas D., Brandon O. Hensley, Kevin E. Wells, T. Jameson Brewer, Daisy Ball, and

Peter McLaren. 2017. "Homophily in Higher Education: Historicizing the AERA Member-to-Fellow Pipeline Using Theories of Social Reproduction and Social Networks." *Policy Futures in Education* 15(6):670–94.

Hazari, Zahra, Philip M. Sadler, and Gerhard Sonnert. 2013. "The Science Identity of College Students: Exploring the Intersection of Gender, Race, and Ethnicity." *Journal of College Science Teaching* 42(5):82–91.

Hazari, Zahra, Gerhard Sonnert, Philip M. Sadler, and Marie-Claire Shanahan. 2010. "Connecting High School Physics Experiences, Outcome Expectations, Physics Identity, and Physics Career Choice: A Gender Study." *Journal of Research in Science Teaching* 47(8):978–1003.

Hernandez, John C. 2000. "Understanding the Retention of Latino College Students." *Journal of College Student Development* 41:575–88.

Hew, Khe Foon and Chung Kwan Lo. 2018. "Flipped Classroom Improves Student Learning in Health Professions Education: A Meta-Analysis." *BMC Medical Education* 18(1):38.

Hill, Mary C. and Kathryn K. Epps. 2009. "Does Physical Classroom Environment Affect Student Performance, Student Satisfaction, and Student Evaluation of Teaching in the College Environment." *Proceedings of the Academy of Educational Leadership* 14(1):15–19.

Hilts, Alexis, Rachel Part, and Matthew L. Bernacki. 2018. "The Roles of Social Influences on Student Competence, Relatedness, Achievement, and Retention in STEM." *Science Education* 102(4):744–70.

Hu, Shouping and Gregory C. Wolniak. 2013. "College Student Engagement and Early Career Earnings: Differences by Gender, Race/Ethnicity, and Academic Preparation." *The Review* *of Higher Education* 36(2):211–33.

Hurtado, Sylvia and Deborah Faye Carter. 1997. “Effects of College Transition and Perceptions of the Campus Racial Climate on Latino College Students’ Sense of Belonging.” *Sociology of Education* 70:324–45.

Jackson, Aaron P., Steven A. Smith, and Curtis L. Hill. 2003. “Academic Persistence among Native American College Students.” *Journal of College Student Development* 44(4):548–65.

Jinlei, Zhang, Wang Ying, and Zhang Baohui. 2012. “Introducing a New Teaching Model: Flipped Classroom [J].” *Journal of Distance Education* 4(8):46–51.

Johnson, Dawn R. 2012. “Campus Racial Climate Perceptions and Overall Sense of Belonging among Racially Diverse Women in STEM Majors.” *Journal of College Student Development* 53(2):336–46.

Kim, Young K. 2010. “Racially Different Patterns of Student-Faculty Interaction in College: A Focus on Levels, Effects, and Causal Directions.” *Journal of the Professoriate* 3(2):161–89.

Kim, Young K. and Linda J. Sax. 2018. “The Effect of Positive Faculty Support on Mathematical Self-Concept for Male and Female Students in STEM Majors.” *Research in Higher Education* 1–31.

Kruse, Sharon D. and Karen Seashore Louis. 2009. *Building Strong School Cultures: A Guide to Leading Change*. Thousand Oaks, California: Corwin Press.

Kuh, George D. 2003. “What We’re Learning about Student Engagement from NSSE: Benchmarks for Effective Educational Practices.” *Change: The Magazine of Higher Learning* 35(2):24–32.

Kyte, Sarah Blanchard and Catherine Riegle-Crumb. 2017. “Perceptions of the Social Relevance of Science: Exploring the Implications for Gendered Patterns in Expectations of Majoring in STEM Fields." *Social Sciences* 6(1):19.

Larsen, Elizabeth A. and Margaret L. Stubbs. 2005. "Increasing Diversity in Computer Science: Acknowledging, yet Moving beyond, Gender." *Journal of Women and Minorities in Science and Engineering* 11(2):139–69.

Lavonen, Jari and Seppo Laaksonen. 2009. "Context of Teaching and Learning School Science in Finland: Reflections on PISA 2006 Results." *Journal of Research in Science Teaching* 46(8):922–44.

Lee, James Daniel. 1998. "Which Kids Can 'Become' Scientists? Effects of Gender, Self-Concepts, and Perceptions of Scientists." *Social Psychology Quarterly* 61(3):199–219.

Lee, Jennifer and Min Zhou. 2015. *The Asian American Achievement Paradox*. New York: Russell Sage Foundation.

Lei, Simon A. 2010. "Classroom Physical Design Influencing Student Learning and Evaluations of College Instructors: A Review of Literature." *Education* 131(1).

Lewis, Amanda E. 2003a. "Everyday Race-Making: Navigating Racial Boundaries in Schools." *American Behavioral Scientist* 47(3):283–305.

Lewis, Amanda E. 2003b. *Race in the Schoolyard: Negotiating the Color Line in Classrooms and Communities*. New Brunswick: Rutgers University Press.

Lockwood, Penelope. 2006. "'Someone like Me Can Be Successful': Do College Students Need Same-Gender Role Models?" *Psychology of Women Quarterly* 30(1):36–46.

Maranto, Cheryl L. and Andrea E. C. Griffin. 2011. "The Antecedents of a 'Chilly Climate' for Women Faculty in Higher Education." *Human Relations* 64(2):139–59.

Margolis, Jane and Allan Fisher. 2002. *Unlocking the Clubhouse: Women in Computing*.

Cambridge, Massachusetts: MIT press.

Margolis, Jane, Allan Fisher, and Faye Miller. 1999. “Caring about Connections: Gender and Computing.” *IEEE Technology and Society Magazine* 18(4):13–20.

Marlone, K. and G. Barabino. 2009. “Narrations of Race in STEM Research Settings: Identity Formation and Its Determinants.” *Science Education* 93:486–510.

Martens, Andy, Michael Johns, Jeff Greenberg, and Jeff Schimel. 2006. “Combating Stereotype Threat: The Effect of Self-Affirmation on Women’s Intellectual Performance.” *Journal of Experimental Social Psychology* 42(2):236–43.

Martin, Sandra Horne. 2002. “The Classroom Environment and Its Effects on the Practice of Teachers.” *Journal of Environmental Psychology* 22(1–2):139–56.

McDonough, Patricia M. 1997. *Choosing Colleges: How Social Class and Schools Structure Opportunity*. Albany: SUNY Press.

Migliaccio, Beth, Omair Sheikh, Caroline Bateman, and James Knopp. 2009. “Gender Differences in Performance in Principles of Biochemistry Based on Bloom’s Taxonomy of Question Difficulty and Study Habits.” *NCSU Undergrad Res J* 5:76–83.

Miner, Kathi N., Samantha C. January, Kelly K. Dray, and Adrienne R. Carter-Sowell. 2019. “Is It Always This Cold? Chilly Interpersonal Climates as a Barrier to the Well-Being of Early-Career Women Faculty in STEM.” *Equality, Diversity and Inclusion: An International Journal* 38(2):226–45.

Momsen, Jennifer L., Tammy M. Long, Sara A. Wyse, and Diane Ebert-May. 2010. “Just the Facts? Introductory Undergraduate Biology Courses Focus on Low-Level Cognitive Skills.” *CBE—Life Sciences Education* 9(4):435–40.

Momsen, Jennifer, Erika Offerdahl, Mila Kryjevskaia, Lisa Montplaisir, Elizabeth Anderson, and

Nate Grosz. 2013. “Using Assessments to Investigate and Compare the Nature of Learning in Undergraduate Science Courses.” *CBE—Life Sciences Education* 12(2):239–49.

Morris, L. K. 2003. “The chilly climate for women: A literature review.” Presented at the Annual Meeting of the Mid-South Educational Research Association, November, Biloxi, MI. Retrieved from ERIC database. (ED482555)

Morris, LaDonna K. and Larry G. Daniel. 2008. “Perceptions of a Chilly Climate: Differences in Traditional and Non-Traditional Majors for Women.” *Research in Higher Education* 49(3):256–73.

National Science Board. 2016. *Science and Engineering Indicators 2016 NSF - National Science Foundation*.

National Science Foundation. 2014. “National Center for Science and Engineering Statistics: Integrated Science and Engineering Resources Data System.” *Integrated Postsecondary Education Data System, 2013, Completions Survey*. Retrieved (https://webcaspar.nsf.gov).

Office of InformationTechnology, University of Colorado Boulder. 2019. “Observation Protocol for Learning Environments | Office of Information Technology.” Retrieved June 4, 2020 (https://oit.colorado.edu/services/academic-technology/projects/teaching-observation-protocol).

Ohland, Matthew W., Sheri D. Sheppard, Gary Lichtenstein, Ozgur Eris, Debbie Chachra, and Richard A. Layton. 2008. “Persistence, Engagement, and Migration in Engineering Programs. Research Brief.” *Journal of Engineering Education* 97(3):259–78.

Olszewski-Kubilius, Paula, Saiying Steenbergen-Hu, Dana Thomson, and Rhoda Rosen. 2017. “Minority Achievement Gaps in STEM: Findings of a Longitudinal Study of Project Excite.” *Gifted Child Quarterly* 61(1):20–39.

Osborne, Jonathan, Shirley Simon, and Sue Collins. 2003. "Attitudes towards Science: A Review of the Literature and Its Implications." *International Journal of Science Education* 25(9):1049–79.

Pascarella, Ernest T. and J. Smart. 1985. "Higher Education: Handbook of Theory and Research." Pp. 1–62 in, edited by J. C. Smart. New York: Agathon.

Pascarella, Ernest T. and Patrick T. Terenzini. 2005. *How College Affects Students: A Third Decade of Research.* San Francisco: Jossey-Bass.

Pietri, Evava S., Erin P. Hennes, John F. Dovidio, Victoria L. Brescoll, April H. Bailey, Corinne A. Moss-Racusin, and Jo Handelsman. 2019. "Addressing Unintended Consequences of Gender Diversity Interventions on Women's Sense of Belonging in STEM." *Sex Roles* 80(9):527–47.

Posselt, Julie R. 2016. *Inside Graduate Admissions: Merit, Diversity, and Faculty Gatekeeping*. Cambridge, Massachusetts: Harvard University Press.

Poysner, Larry R. 1983. *An Examination of the Classroom Physical Environment.* South Bend: Indiana University at South Bend.

Redmond-Sanogo, Adrienne, Julie Angle, and Evan Davis. 2016. "Kinks in the STEM Pipeline: Tracking STEM Graduation Rates Using Science and Mathematics Performance." *School Science and Mathematics* 116(7):378–88.

Riegle-Crumb, Catherine and Barbara King. 2010. "Questioning a White Male Advantage in STEM Examining Disparities in College Major by Gender and Race/Ethnicity." *Educational Researcher* 39(9):656–64.

Rine, P. Jesse. 2014. *Strengthening the STEM Pipeline: The Contributions of Small and Mid-Sized Independent Colleges.* Washington D.C.: Council of Independent Colleges.

Rivera, Lauren A. 2012. “Hiring as Cultural Matching: The Case of Elite Professional Service Firms.” *American Sociological Review* 77(6):999–1022.

Roehl, Amy, Shweta Linga Reddy, and Gayla Jett Shannon. 2013. “The Flipped Classroom: An Opportunity to Engage Millennial Students through Active Learning Strategies.” *Journal of Family & Consumer Sciences* 105(2):44–49.

Schneider, Michael and Franzis Preckel. 2017. “Variables Associated with Achievement in Higher Education: A Systematic Review of Meta-Analyses.” *Psychological Bulletin* 143(6):565.

Schnitman, Marissa Leigh. 2014. “The Price of Unpaid Internships.” Honors Thesis, Department of Education, Wesleyan University.

Seymour, Elaine. 2002. “Tracking the Processes of Change in US Undergraduate Education in Science, Mathematics, Engineering, and Technology.” *Science Education* 86(1):79–105.

Seymour, Elaine and Nancy M. Hewitt. 1997. *Talking About Leaving: Why Undergraduates Leave the Sciences.* Oxford: Westview Press.

Shapiro, Jenessa R. and Amy M. Williams. 2012. “The Role of Stereotype Threats in Undermining Girls’ and Women’s Performance and Interest in STEM Fields.” *Sex Roles* 66(3–4):175–83.

Sjøberg, Svein and Camilla Schreiner. 2005. “How Do Learners in Different Cultures Relate to Science and Technology? Results and Perspectives from the Project ROSE (The Relevance of Science Education).” *Asia-Pacific Forum on Science Learning and Teaching* 6(2):1–17.

Spencer, Steven J., Claude M. Steele, and Diane M. Quinn. 1999. “Stereotype Threat and Women’s Math Performance.” *Journal of Experimental Social Psychology* 35(1):4–28.

Steele, Claude M. and Joshua Aronson. 1995. “Stereotype Threat and the Intellectual Test

Performance of African Americans." *Journal of Personality and Social Psychology* 69(5):797–811.

Strenta, A. Christopher, Rogers Elliott, Russell Adair, Michael Matier, and Jannah Scott. 1994. "Choosing and Leaving Science in Highly Selective Institutions." *Research in Higher Education* 35(5):513–47.

Tavory, Iddo and Stefan Timmermans. 2014. *Abductive Analysis: Theorizing Qualitative Research*. Chicago: University of Chicago Press.

Teo, Tang Wee and Margery Osborne. 2014. "Understanding Accountability from a Microanalysis of Power Dynamics in a Specialized STEM School." *Critical Studies in Education* 55(2):229–45.

Thomson, Margareta M., Zarifa Zakaria, and Ramona Radut-Taciu. 2019. "Perceptions of Scientists and Stereotypes through the Eyes of Young School Children." *Education Research International* 2019:1–13.

Tinto, Vincent. 1987. *Leaving College: Rethinking the Causes and Cures of Student Attrition.* Chicago: University of Chicago Press.

Tinto, Vincent. 1998. "Colleges as Communities: Taking Research on Student Persistence Seriously." *The Review of Higher Education* 21(2):167–77.

Tobias, Sheila. 1990. "Stemming the Science Shortfall at College." in *They're not dumb, they're different*, edited by S. Tobias. Tucson, AZ: Research Corporation.

Tobias, Sheila. 1992. "Science Education Reform What's Wrong with the Process?" *Change: The Magazine of Higher Learning* 24(3):12–19.

Toth, Linda S. and Linda G. Montagna. 2002. "Class Size and Achievement in Higher Education: A Summary of Current Research." *College Student Journal* 36(2):253–61.

US Census Bureau. 2012. *Men and Women Working in STEM*.

Valkenburg, M. E. Van. 1990. “An Engineering Curriculum for the Future.” *IEEE Communications Magazine* 28(12):12–15.

Walton, Gregory M., Christine Logel, Jennifer M. Peach, Steven J. Spencer, and Mark P. Zanna. 2015. “Two Brief Interventions to Mitigate a ‘Chilly Climate’ Transform Women’s Experience, Relationships, and Achievement in Engineering.” *Journal of Educational Psychology* 107(2):468.

Weber, Max. 1946. “Structures of Power.” Pp. 159–79 in *From Max Weber: Essays in Sociology*. Vol. 1, edited by H. H. Gerth and C. W. Mills. London: Routledge & Kegan Paul.

Wile, Amanda J. and Gary A. Shouppe. 2011. “Does Time-of-Day of Instruction Impact Class Achievement?” *Perspectives in Learning* 12(1):9.

Wilson, Timothy D. and Nicholas R. Buttrick. 2016. “New Directions in Social Psychological Interventions to Improve Academic Achievement.” *Journal of Educational Psychology* 108(3):392.

Woodford, Michael R., Alex Kulick, and Brittanie Atteberry. 2015. “Protective Factors, Campus Climate, and Health Outcomes among Sexual Minority College Students.” *Journal of Diversity in Higher Education* 8(2):73.

Wright, Christian D., Sarah L. Eddy, Mary Pat Wenderoth, Elizabeth Abshire, Margaret Blankenbiller, and Sara E. Brownell. 2016. “Cognitive Difficulty and Format of Exams Predicts Gender and Socioeconomic Gaps in Exam Performance of Students in Introductory Biology Courses.” *CBE—Life Sciences Education* 15(2):23–29.

Xie, Yu, Michael Fang, and Kimberlee Shauman. 2015. “Stem Education.” *Annual Review of*

Sociology 41:331–57.

Table 1.1. Percentages of Students Enrolled in Computer Science or Biology Courses at the Private University in 2018-19

All enrolled Students			**Students by Major In total numbers**	
Ethnicity	**CS %**	**Bio %**	**CS**	**Bio**
Total	100%	**100%**	**38**	**338**
Am. Indian	0.0%	0.1%	0	0
Asian	25.9%	33.6%	10	116
Black	3.5%	8.0%	1	25
Hispanic	5.8%	10.6%	1	36
Multi	3.2%	4.1%	1	21
Non US Citizen	39.5%	10.9%	15	39
Unknown	0.0%	1.3%	1	6
White	22.1%	31.4%	9	95
Gender				
Female	38.9%	60.6%	8	212
Male	61.1%	39.4%	30	126

Figure 1.1. GORP Hayward Protocol (Adapted from OPLE – CU Boulder)

Figure 1.2. Summary Chart of Hayward Protocol Recordings by Code Over Entire Semester

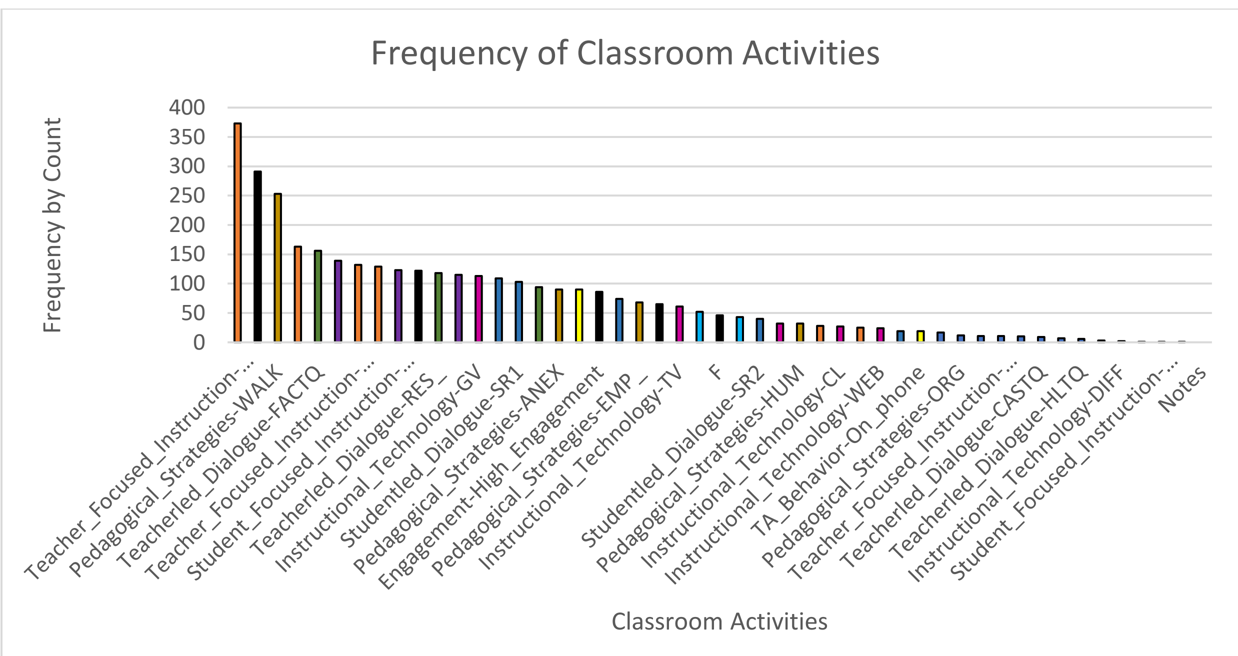


Figure 1.3. Class Time by Code of Computer Science Lecture-Hall During Fractal-Tree Lesson

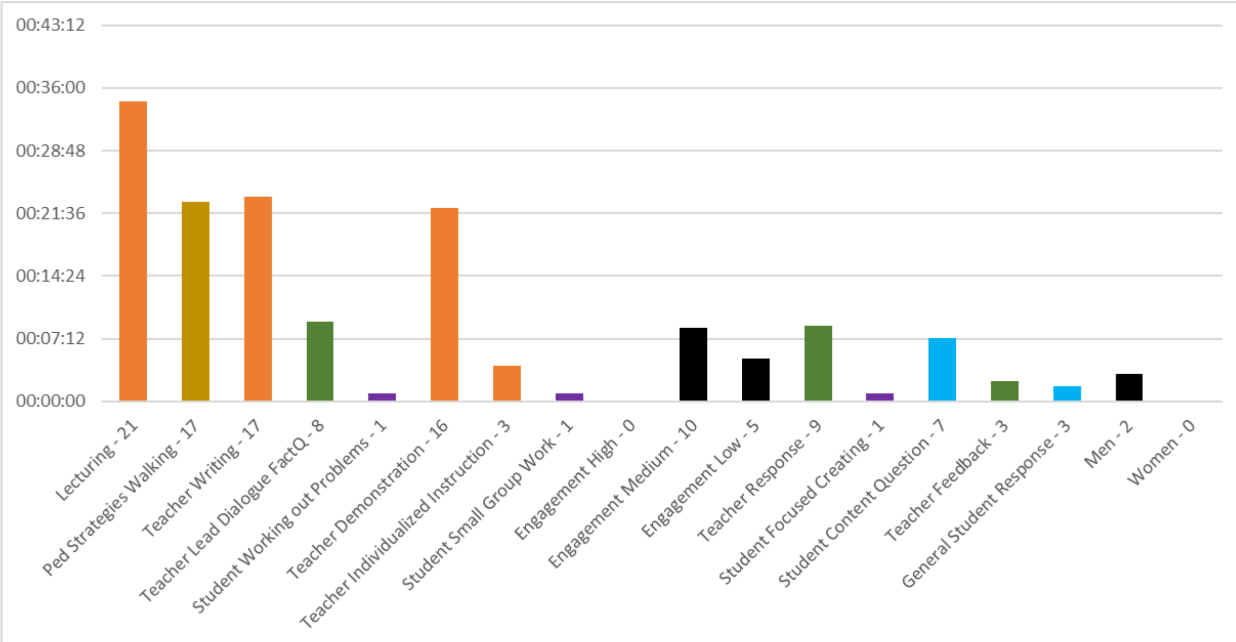


Figure 1.4. Class Time by Code of Computer Science Round-Table During Fractal-Tree Lesson

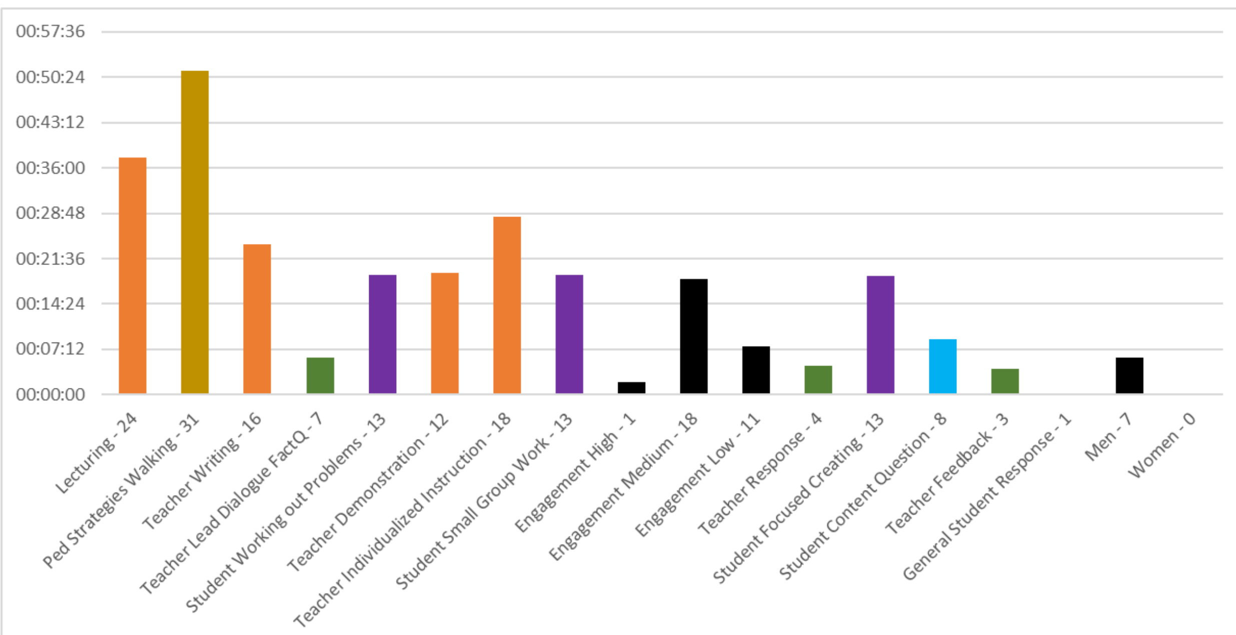


Figure 1.5. Class Timeline by Code of Biology Lecture During Glycolysis Activity

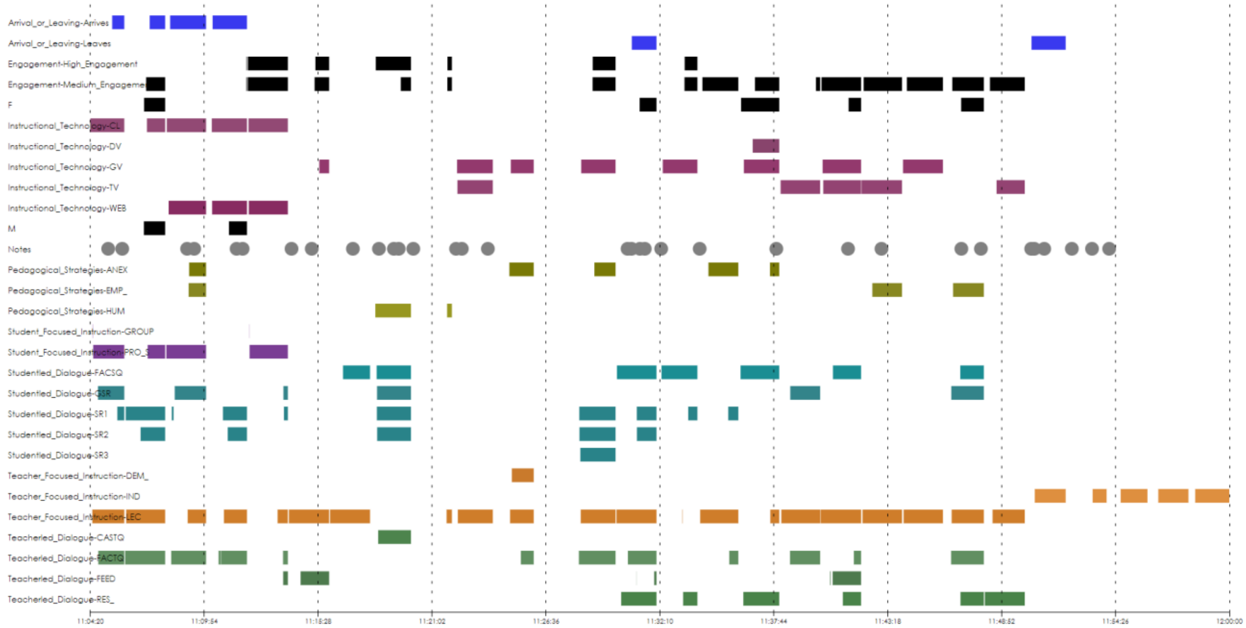


Figure 1.6. Class Time by Code of Biology Lecture During Cancer Unit

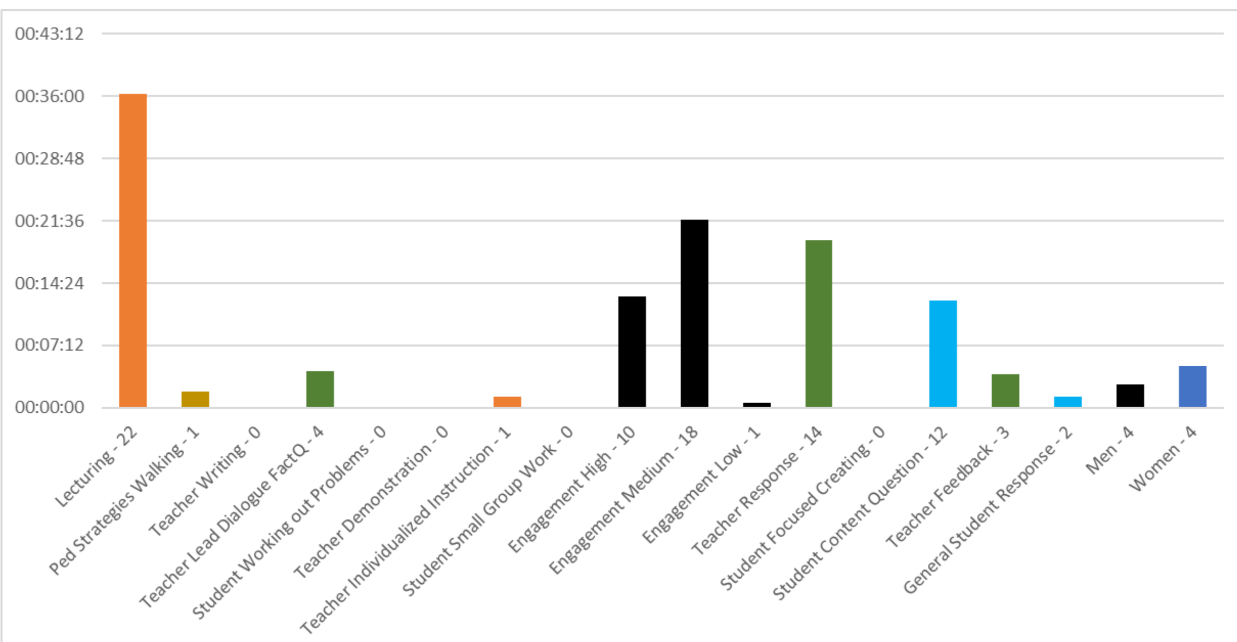


Figure 1.7. Class Timeline by Code for Computer Science Lecture on Writing Code to Order Pizza

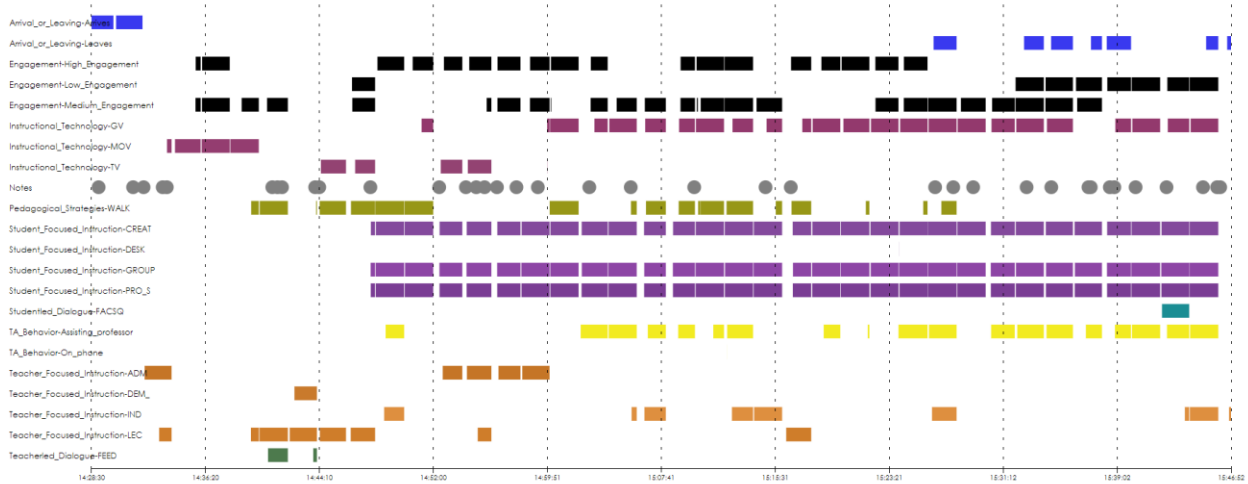


Figure 1.8 Chart of Hayward Protocol Recordings by Computer Science and Biology

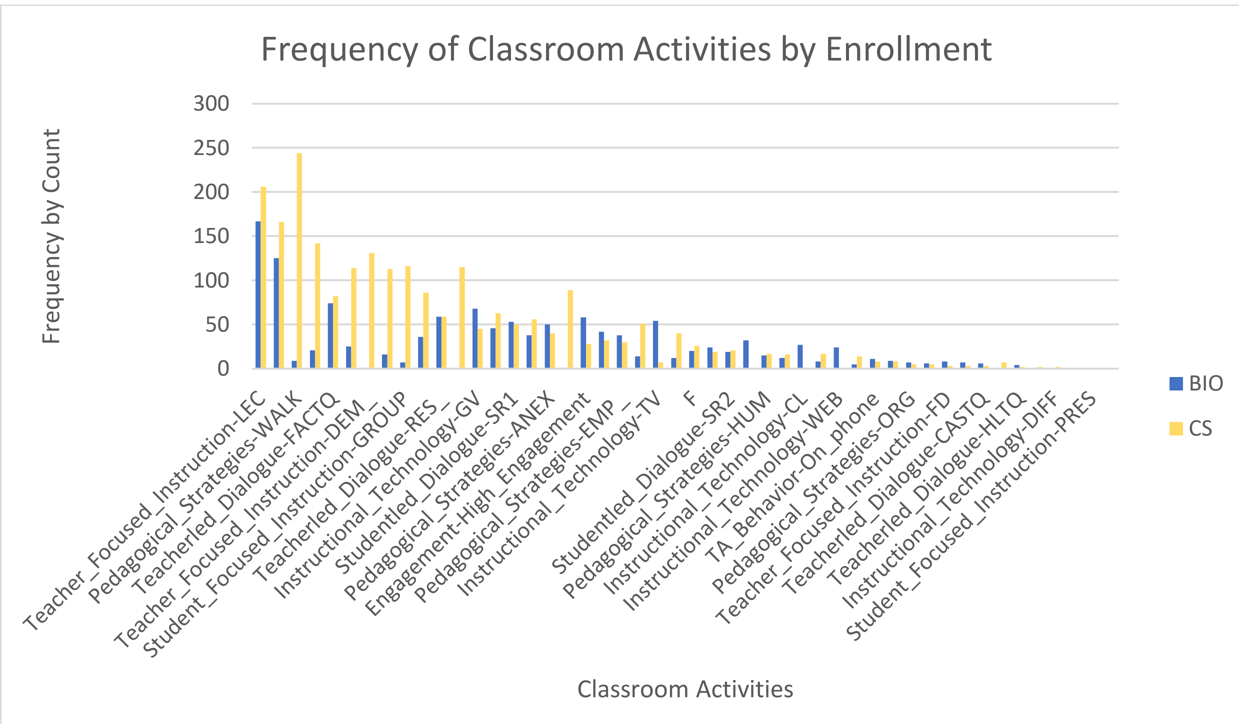
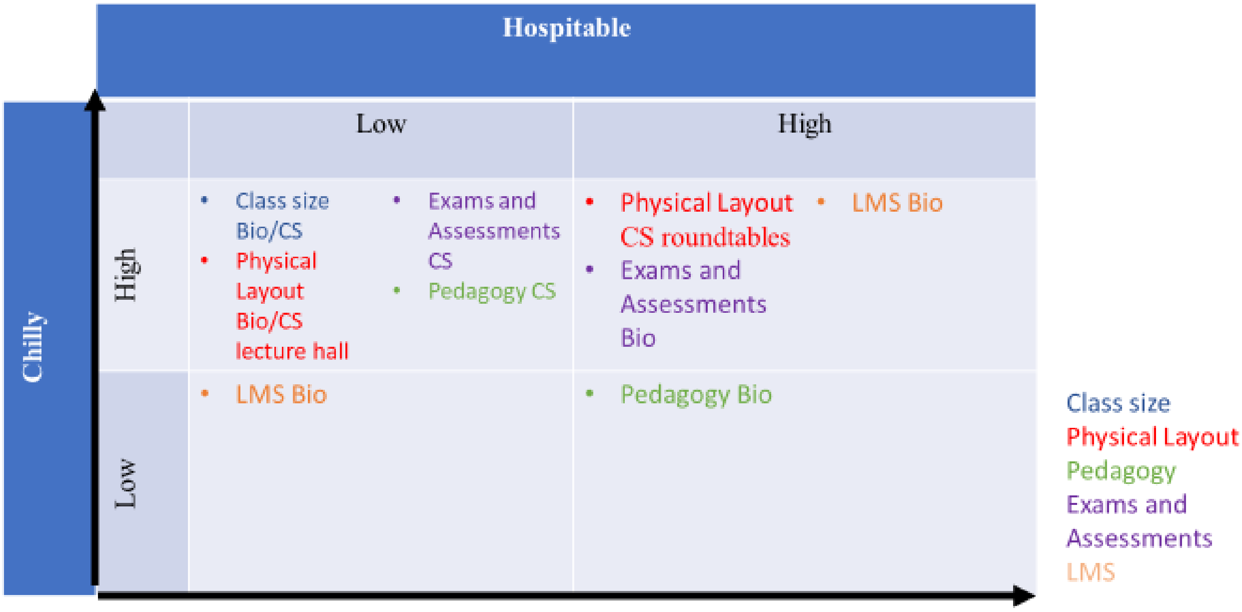


Figure 1.9. Chart of Dimensions of the Classroom



Chapter 2: Effects of Fairness and Social Characteristics on Undergraduate STEM Students' Emotions and Perceptions of Competence

Introduction

STEM fields have a history of challenges in recruiting and retaining individuals from diverse backgrounds. According to the 2010 US Census Bureau, less than eight percent of Science, Technology, Engineering, and Math (STEM) employees are underrepresented minorities (URMs) (African American, Hispanic or Latino/Latina & American Indian). STEM departments are generally seen as unwelcoming to women and URMs (Foster 1994; Morris 2003). Yet most of the research examining factors related to entering STEM fields focuses not on characteristics of departments or dynamics of classes therein but on the importance of students' interest, previous experience, competence (measured by GPA), perceptions of course difficulty, attitudes, values, as well as characteristics of their socioeconomic status, gender, and race and ethnicity (Eccles 1989; Holland 1997; Lent et al. 2005; Watt and Eccles 2008).

The thrust of my study answers Xie, Fang, and Shauman's (2015) call for examining social psychological factors shaping participation and achievement in STEM fields to interrogate the continuing diversity gaps in STEM education. I move beyond the typical factors of students' background and characteristics shaping participation in STEM fields to consider whether students themselves perceive the dynamics in STEM classrooms, and associate these classroom dynamics with their broader thoughts about the field. To do so, I examine students' assessments of classroom dynamics, which in turn are likely to shape their immediate and long-term reactions to their STEM experiences. Specifically, guided by premises of justice (e.g., Jost and Kay 2010) and status processes (Berger et al. 1980), I focus on how students' perceptions of the social dynamics unfolding in their STEM classes shape their emotional responses to such classes and their own perceptions of competence.

Justice (or fairness) plays an important role in all social groups, and is especially important for students, as they spend the majority of their time in schools.[1] Issues of justice arise in contexts comparing actual distributions of a valued resource from what might have been expected based on a particular distribution rule (distributive justice), the decision-making underlying the distribution (procedural justice), and the general treatment of potential recipients of the resource (interpersonal justice) (Jost and Kay 2010). People make assessments about whether distributed outcomes, processes of decision-making, or their interactions are "fair" or "unfair," which in turn stimulates affective (which comprise both positive and negative emotions), cognitive, and behavioral responses affecting interpersonal and organizational dynamics (Hegtvedt 2018). For example, students who receive a poor grade in a course often make a decision about whether that poor grade was "fair" based on the grade itself, on how that grade was decided, and on their interactions with the person assigning the grade.

At the same time, status processes, which describe how individuals' status characteristics (e.g., gender, race, socioeconomic status) shape the formation of hierarchies within STEM and influence patterns within groups (classrooms, students within a major) (Webster and Foschi 1988), stimulate similar affective, cognitive, and behavioral responses. Lawler and Thye (2006) define affective responses, or emotions as something internal to a person stemming from conditions or events external to him or her that take various forms, and tend to range from positive to negative. Competence involves individuals' knowledge and understanding of content and is an especially important factor for a STEM major. Few studies bring together both affective and cognitive responses, as I do in this study. Yet, both potentially propel future behaviors (Fiske and Taylor 2013; Turner and Stets 2005), including continuation or discontinuation in STEM pursuits.

To investigate how students' perceptions of justice and status processes shape STEM students' emotions and views of their competence I use survey data collected from students (n=786) at a private university. Findings from these surveys indicate that STEM students' concerns about their outcomes (i.e., fairness of grades) and treatment from their professors shape their emotional responses, whereas considerations of interpersonal justice (by both professors and peers) shape their assessments of competence. In other words, students' grades and fair treatment from professors and peers shape how competent students believe they are. Results also suggest that gender shapes both individuals' emotions and assessments of competence, while race only shapes competence and SES only shapes students' emotions. Overall, this suggests that justice and status processes in the classroom may ultimately matter for students' persistence in and for reducing disparities in STEM fields.

Conceptualizing Emotional and Cognitive Assessments in the Classroom

As previously noted, emotions and cognitions drive behavior. I begin by outlining briefly how they do so. Then, in subsequent sections, I delve more specifically into how justice and status processes shape affective and cognitive responses to classroom dynamics.

Individuals' emotions frequently have important effects on future interactions and relationships (Turner and Stets 2005). Interactions that leave individuals feeling positively (gratitude, happiness) are likely to encourage a future relationship that may endure over time, while interactions that make people feel negative emotions (anger, shame) are likely to discourage future interactions and the development of a future relationship. Some research demonstrates how such patterns of emotion relate to career aspirations. For example, Schuster and Martiny (2017) find that measurements of women's *anticipation* of more negative affect and less positive affect in STEM fields lowered their STEM career aspirations. My study builds on this research with direct measurements of students' affective responses to their STEM course experiences, and links these feelings with their perceptions of justice and status processes. When professors show students that their ideas and efforts are valued within the classroom, students may feel positive emotions and increased confidence in their own competence.

Students' perceptions of their competence shape the major that they ultimately choose. If students do not feel competent within a discipline, they are likely to choose another (Maltese and Tai 2011; Monforti and Michelson 2008), or leave the university entirely (Adamuti-Trache and Andres 2008). Researchers, however focus on the role of competence in participation in STEM fields (e.g., Eccles 1989; Watt and Eccles 2008), relying on objective measures such as GPA or standardized test scores. Scholars likewise employ such objective measures when examining the effects of demographic factors such as gender (Shapiro and Williams 2012; Simon, Wagner, and Killion 2017), race, and SES (Oakes 1990), of individual motivation and efficacy (Areepattamannil, Freeman, and Klinger 2011; Chemers, Hu, and Garcia 2001; Trujillo and Tanner 2014), and of parental valuation of science (Ratelle et al. 2005; Sun, Bradley, and Akers 2012) on science competence. These more objective measurements fail to take into account how students interpret the meaning of these measurements and how their perceptions influence their reactions. Distinct from this previous work, in this study I focus on students' own assessments of their competence (rather than indicators like GPA or test scores) as shaped by the interaction dynamics they observe and experience in their entry level STEM courses rather than motivational or parental factors. This focus provides a means to understanding the ways classroom dynamics shape how students evaluate their competence within STEM, which, in turn, may help to identify actions under instructors' control that enhance their students' persistence in STEM, especially among URMs.

In what follows, I draw upon fundamental processes in social psychology, justice and status, to characterize what unfolds in classrooms. I argue that the perception of unjust outcomes, procedures, or interactions, especially those revolving around status characteristics, produces less positive emotion and greater negative emotion and attenuates assessments of competence.

Conceptualizing Justice Processes

Research clearly confirms that perceived justice or fairness within organizations positively affects individuals' attitudes, such as their job satisfaction and commitment to the work group (Brockner et al. 1990; Colquitt 2001; McFarlin and Sweeney 1992). Such patterns regarding organizations in the corporate world extend to the sphere of educational institutions as well (Sabbagh and Resh 2016). College students experience issues surrounding justice regarding the distribution of important resources such as: knowledge, skills, mentoring, grades, and ultimately credentials. Moreover, students have concerns about how their instructors make those decisions about resource distributions (e.g., how grades are calculated) and about how both the instructors and their classroom peers treat them. Such considerations pertain, respectively, to distributive, procedural, and interactional justice.

Justice pertains to dynamics involving both authority and peers in a social situation and may involves three types: *distributive* (regarding fair distributions); *procedural* (pertaining to decision-making processes relevant to distributions); and *interpersonal* (involving being treated with honesty and human dignity).[2] Although the different justice types may be correlated in some situations, meta-analysis indicates that they are conceptually distinct and the variation provided by investigating the impact of each individually offers more explanatory value (Colquitt et al. 2001). I focus on students' assessments of distributive, procedural, and interpersonal justice regarding their classroom experiences, examining *how* each type of justice shapes their affective and cognitive responses.

Distributive justice (DJ) (Adams 1965; Deutsch 1985; Homans 1974; Leventhal 1976) specifically involves principles governing the nature of the distribution of resources, outcomes, rewards, or burdens within a group or organization (Jost and Kay 2010). It applies a normative rule to the allocation of benefits or burdens to recipients (Hegtvedt 2018). Principles such as equality (all recipients receive the same level of outcomes) or equity (recipients receive outcomes commensurate to their contributions or inputs; and ratios across recipients should be equivalent) define expectations associated with distributive justice.

Procedural justice (PJ) (Leventhal, Karuza, and Fry 1980; Thibaut and Walker 1975) concerns principles pertaining to the decision-making process in regard to the allocation of resources, access to resources, and evaluations of performance. Leventhal and colleagues (1980) offer six rules to ensure procedural fairness. Procedures should "(a) be applied consistently across people and across time, (b) be free from bias (i.e. no vested interests in a particular settlement), (c) ensure that accurate information is collected and used in making decisions, (d) have some mechanism to correct flawed or inaccurate decisions, (e) conform to personal or prevailing standards of ethics or morality, and (f) ensure that the opinions of various groups affected by the decision have been taken into account" (qtd. in Colquitt et al. 2001: 426). Consideration, consciously or unconsciously, of these six rules shape an individual's perception that the decision-making process that determines the distributions of outcomes in a situation is fair.

Interpersonal justice (IJ), concerns the interpersonal treatment individuals receive from others. In the literature researchers also refer to this interpersonal treatment as the social interactional or interactional justice that focuses on the quality of interpersonal treatment when decision-making procedures are implemented (Bies and Moag 1986). An emphasis on treating people with dignity and respect constitutes IJ (Bies 2001; Bies and Moag 1986).

To determine whether fairness exists, regardless of the type of justice utilized in a judgment, evaluators (in this case, students) assesses information available in the relevant context. Evaluations of justice are subjective, and involve a sense making process influenced by who people are (individual-level factors) and the situations (contextual-level factors) in which they are embedded (Hegtvedt 2018). Individuals' motivations (material self-interest, social concerns, and moral convictions) and social positions, create varied perceptions of fairness by different individuals of the same situation (Hegtvedt 2018). In the classroom, students who maintain different positions are likely to interpret differently the procedures, contributions, outcomes, and treatment. For example, what a white male perceives as fair may not seem fair to URMs.

The Effects of the Justice Types on Emotions

The principles relevant to each type of justice consciously or subconsciously inform individuals' expectations for the way a situation may unfold, thereby anchoring perceptions of injustice. When a situation does not proceed according to expectations (e.g., people receive lower outcomes than expected based on their inputs, decision-making violates procedural justice principles, or treatment is disrespectful), people are likely to perceive injustice. Perceptions of injustice stimulate distress, which people are motivated to relieve (Adams 1965; Folger et al. 2006; Homans 1974). Negative emotions such as anger and resentment capture that distress resulting from perceived injustice whereas perceptions of justice produce positive emotions like satisfaction and contentment. A number of studies confirm these expected patterns (see Cropanzano, Stein, and Nadisic 2011; Hegtvedt and Parris 2014). For example, extrapolating to the classroom setting, students' reactions to unjust distributions, procedures, or interactions with their professors and peers may generate emotions, stimulating further reaction in the situation.

How students perceive the fairness of their experience in class—including their assessments of the distribution of outcomes, procedures, and interactions with professors and peers—should shape the emotions that they report. Students' expectations, based on the principles of justice, combined with their observations of actual outcomes, procedures, and interactions inform their justice evaluations. Following justice perspectives predicting distress resulting from perceived injustice and satisfaction or other positive emotions from perceived justice (Adams 1965; Homans 1974), I predict:

Hypothesis 1: Perceived justice is positively related to positive emotions and negatively related to negative emotions.

As discussed previously, although perceptions of distributive, procedural, and interpersonal justice may be correlated and have similar effects on students' experiences of emotions, I expect that interpersonal justice and distributive justice will matter more than procedural justice in shaping students' emotions. Individuals, in this case students, can readily gauge the quality of their interpersonal relationships with others (their professors and peers) through factors like neutrality (Lind and Tyler 1992), which emphasizes equal treatment of all parties with honesty and a lack of bias. Additionally, students' likely focus on grades increases the salience of distributive justice concerns.

Students draw on their interpersonal treatment from professors and other students to decide how to evaluate their standing within the group. People want to feel they are a valued member of a valuable group, and look to their treatment in the group to evaluate their standing (Lind and Tyler 1988). Fair treatment communicates to individuals that they are valued members of the group; conversely, unfair treatment communicates they are not valued members of the group. Feeling like a valued member of a valued group is likely to increase positive emotions, while feeling like an unvalued member of a group is likely to increase negative emotions. IJ is also positively associated with emotional arousal (Stecher and Rosse 2005), and organizational commitment (Barling and Phillips 1993), while interpersonal injustice cultivates anger (Bies and Tripp 1996). Thus, students who experience IJ are likely to feel stronger ties to their group (i.e., their STEM major), but students who experience interpersonal injustice are likely to feel anger that will distance them from their group. While procedural justice also conveys to individuals their value to the group, it does so in a more impersonal way, via decision-making processes, not necessarily face to face dynamics. Research indicates that social connectedness and belonging to a group is critical for college students and their well-being (Allen et al. 2008; Lee and Robbins 1995; Tellhed, Bäckström, and Björklund 2017). Accordingly, interpersonal justice signals more proximal group connectedness and belonging than procedural justice (Kurdoglu 2019).

Distributive justice is also likely to matter more than fairness in decision-making procedures given the value to students of college grades distributed by professors to students. Many students experience extreme affective distress during college surrounding their grades (Papanikolaou et al. 2003; Struthers, Perry, and Menec 2000). Grades have significant effects on students' self-esteem, emotions, and perceptions of their self-worth (Crocker et al. 2003; Stupnisky et al. 2013). Especially in the current context of increasing college costs, and a heightened awareness of the importance of doing well in college to ensure strong future job prospects, students place a lot of weight on their grades, and maintaining a high GPA in college. While students' own actions contribute to the grades that they receive, they often do not have much control or input on the classroom rules and procedures, thus the fairness of the distributed grades may matter more than underlying decision-making procedures for the class. Overall, students may perceive more individuation in terms of their interpersonal treatment (IJ) and outcomes (DJ) that they receive than in terms of decision-making procedures. I predict that

> *Hypothesis 2:* Interpersonal and distributive justice are likely to have stronger effects on emotions than procedural justice.

The Effects of Justice Types on Competence

Beyond emotional responses to perceived justice, individuals look to the fairness of authorities to assess the security of their position in a group or organization (van den Bos, Lind, and Wilke 2001), which has consequences for their cognitive responses in the situation. That is, students' perceptions of justice and their treatment within a group will also shape how competent they perceive themselves to be. As previously noted, people care about justice (especially interpersonal and procedural) because it communicates to them their value to the group, and underlies their sense of belongingness within the group (Lind and Tyler 1988, 1992; Tyler and Blader 2000). Students who feel confident that they belong in the group (as affirmed through their fair treatment within the group) may take the initiative in contributing ideas to the group. In do so, they may grow more confident as their ideas are debated and/or accepted by the group, which thereby increases their level of perceived competence. In contrast, in the absence of the experience of perceived fairness, people lack a sense of value to and belongingness in the group, which may inhibit their confidence in contributing to it. Consequently, a potential basis for feedback about one's competence dissipates. Moreover, individuals may respond to perceived unfairness by lowering their inputs to be consistent with the lack of fair treatment. Doing so may erode their cognitions about their own competence regarding course materials. Thus, I propose:

> *Hypothesis 3:* Perceived justice is positively related to competence.

Similar to the individual effects of justice on students' emotions, I also expect that the effects of the justice types will vary in their impact on students' assessments of their competence. Specifically, I expect that distributive justice will have the greatest impact on students' perceived competence. Justice behaviors in the classroom provide information to students about the perceptions other students and professors have of their ability to contribute to the intellectual community of the classroom. For students, one of the most important signals of their contributions to the intellectual community is in the form of grades. In addition to the distribution of grades, other "resources" in the classroom such as feedback, professor attention, or time for their questions and concerns during office hours serve as information in forming justice assessments. Depending on the size of the course, students are often competing for these valued resources (especially attention and time during office hours) from the professor with other students.

As indicated with regard to emotions, students care a lot about their grades in college and their grades affect their mental well-being (Banks and Smyth 2015; Miller 2008; Papanikolaou et al. 2003; Trockel, Barnes, and Egget 2000). Ensuring a good grade may even propel students to take "easier" courses (Shim and Ryan 2005; Walker, Greene, and Mansell 2006). Students' grades and the feedback they receive serve as a form of distribution of rewards to students, individualized for their diligent and proficient work in the class. And, as already described, students have control over their performance at some level, distinct from their lack of influence procedural justice. And, especially in large introductory classes, students are less likely to have many one-on-one meetings to perceive an impact of control over interpersonal justice processes with professors compared to outcomes forming the basis of distributive justice assessments. Insofar as grades that students receive are perceived to be a unique measurement of their accomplishments within the class, I expect that grades (as a measure of DJ) in a course should have the greatest impact on their evaluations of their competence:

> *Hypothesis 4***:** Perceived distributive justice is likely to have stronger effects on competence than other forms of justice.

Status Processes in Classroom Dynamics

While respectful treatment from others conveys one's value and position within the hierarchy of the group, status processes provide information about more global, societal views on their contributions and value to the group. Status is "a position in a set of things that are rank-ordered by a standard of value" (Ridgeway and Walker 1995:281). These status rankings are generally determined by the societal structure within which the group exists, that nonetheless shape how the group operates. Status processes unfold in newly formed groups as individuals use limited, but often observable information about other members, especially their status characteristics, to make inferences about their competence and likely performances (Berger, Cohen, and Zelditch 1972; Berger et al. 1980). Status characteristics are attributes on which people differ (e.g., gender and math expertise), and for which there are widely held beliefs associating one attribute as more worthy and valued than another state of that characteristic (high math expertise is better than low math expertise). *Diffuse status characteristics* (DSCs), such as race/ethnicity, gender, and age, carry very general expectations for competence across a variety of situations. *Specific status characteristics* (SSCs) (e.g., math expertise), carry specific expectations for competence in a limited range of situations, typically becoming salient based on perceived relevance of the characteristic to the task at hand (Berger et al. 1972, 1980; Berger and Conner 1974).

Conceptualizing Status Processes and Competence

According to status characteristics theory (Berger et al. 1980), individuals will utilize the most readily available information—often the more visible DSCs—to assume individuals' competence (Berger et al. 1980), creating performance expectations (i.e., generalized anticipations of an individual's capacity to make useful contributions to the group compared to others). Typically, those with higher levels of status characteristics are presumed to be more competent and to take and to receive more action opportunities and thereby exert more influence.

Although reliance on SSCs is more accurate in guiding performance expectations for the self and others than DSCs, individuals nonetheless continue to use of DSCs in assessing task competence. This pattern explains why people offer men, compared to equally performing women more opportunities to participate, more attention, and more credit for ideas and give them higher evaluations and greater rewards (Berger et al. 1980; Ridgeway 2011). A similar pattern holds for race, both whites and blacks talk to whites more in task groups, and evaluate the work of whites more highly, independent of actual performance (Berger and Fişek 2006; Berger, Ridgeway, and Zelditch 2002; Ridgeway 2006).

In the classroom, status characteristic theory would suggest that a student's status determines their ability to participate, to have their contributions to the group accepted or acknowledged, and to influence the actions of the group. Students' observable diffuse status characteristics include gender and race. In contrast, information on specific status characteristics like math or science ability is less observable. Based on initial assumptions students make about the competence of other students, status orders emerge in the classroom. These status orders shape students' opportunities for and barriers to getting the most out of their classroom experiences. When students believe instructors and peers presume less competence owing to their DSCs than others, students then perceive their competence to be low and will likely participate less in class. If students characterized by lower status do participate, they may find that their ideas are less likely to be accepted and supported by others. In contrast, students with higher levels of DSCs are likely to feel highly evaluated by their peers and instructors. With confidence in their own competence they are likely to participate more, exert more influence, and expect higher outcomes than those with lower status. Thus,

> *Hypothesis 5:* Students characterized by the lower value of a diffuse status characteristic (DSC) (i.e., women, students of color, and low SES students) are likely to perceive themselves as having lower competence than students characterized by a higher value of a DSC.

The Effects of Status on Emotions

Beyond the theorized effects of status level on competence, status also carries implications for emotions in social groups. Individuals desire valuable social resources like status. Status differences generate different consequent or situational emotions (Kemper 1978; Ridgeway and Johnson 1990) and affect the interactions of low- and high-status actors (Lovaglia and Houser 1996; Willer, Lovaglia, and Markovsky 1997). As mentioned previously, in the classroom, status characteristics theory suggests students will use DSCs as a mental shortcut to anticipate behaviors from other students, creating a status structure based on the group's expectations for individual contributions to the group. A gain of status (in the form of anticipated useful contributions) is likely to result in positive emotions, while a loss of status (in the form of anticipated unhelpful contributions) is likely to result in negative emotions (Kemper 1978, 1987).

These emotions are also shaped by the attributions individuals make as to *why* they gained or lost status (Kelley 1967; Kemper 1987; Weiner, Nierenberg, and Goldstein 1976). The positive emotions individuals feel as a result of gaining status are likely to be stronger to the extent that individuals are able to attribute the gain in status to something internal, such as their own ability (Kemper 1987). Alternatively, students are more likely to feel stronger negative emotions if they attribute their low status to an external cause such as teacher's bias than to their lack of academic ability. Students with lower value DSCs are more likely to experience restricted action opportunities and low status in the classroom. People experience more negative emotions such as irritation or annoyance when their efforts to participate in the group are blocked (Berkowitz 1978, 1989; Dollard et al. 1939). In contrast, students characterized by higher value DSCs who feel their contributions are valued and accepted are likely to experience more positive emotions. Thus,

> *Hypothesis 6:* Students characterized by the lower value of a diffuse status characteristic (DSC) (i.e., women, students of color, and low SES students[3]) are likely to experience fewer positive emotions and more negative emotions than students characterized by a higher value of a DSC.

Methods and Data Sources

My study aims to illustrate how the nature of classroom interactions, highlighting justice and status processes, in introductory STEM courses shape emotions and competence. I collected data from introductory courses in two disciplines that might range in their justice processes in order to include greater variation in students' experiences: biology and computer science. Women and racial minorities remain underrepresented in the STEM workforce, with the greatest disparities occurring in engineering, computer science, and the physical sciences (National Science Board 2016). Comparatively, the biological sciences more successfully engage a diverse array of students (Sjøberg and Schreiner 2005). My analysis takes these contrasts into account by controlling for discipline.

I selected introductory courses as the focus of this study, because they act as gatekeepers (Seymour and N. M. Hewitt 1997; Tobias 1990). Gatekeeper courses refer to classes with high enrollment that generally represent the introductory courses required for matriculation into a major field of study (Tobias 1992), while also tending to have high enrollment, high levels of competition, large class sizes, and high failure rates (Tobias 1992; Valkenburg 1990). Particularly for science, math, and engineering majors, these courses represent the first course in a series required to graduate from the major. In addition, these courses are the first opportunity for students to learn more about the discipline, as well as the disciplinary norms and the ways each discipline approaches problems. Research finds that student performance in STEM gatekeeper courses helps to predict students who will graduate with a STEM degree, with a non-STEM degree, and those who will not graduate (Redmond-Sanogo et al. 2016), thus making introductory courses a useful place to observe students' initial foray into the STEM field in their undergraduate careers.

Sample

Study participants took either an introductory biology or computer science class during fall semester 2017 (n=388) and 2018 (n=398) at a R1 private university. In the 2018-19 academic year the private university enrolled about 7,916 undergraduate students, with 41 percent white (non-Hispanic), 19 percent Asian, 17 percent non-resident international students, 8 percent black (non-Hispanic) students, and 9 percent Hispanic/Latino students (with 4 percent identifying as multiracial and 2 percent unknown). Table 2.1 shows the racial and gender representation of enrolled and major students in the biology and computer science department. In 2019, around 1,900 bachelor's degrees were awarded, with 338 students with a degree concentration in biology, and 38 in computer science. This university was selected for its diverse student population by race, and as a site where the introductory courses did not have any pre-requisites or specific intro courses segregating students by major or non-major. In addition, R1 schools in particular perform better than public institutions in students' persistence and degree completion rates in STEM fields, while also producing students who are actively recruited to work in STEM fields (Rine 2014).

[Table 2.1 about here]

Across the two semesters, 402 students enrolled in the biology course and 384 enrolled in the computer science course. These numbers represent students from four sections of Introduction to Biology, and six sections of Introduction to Computer Science. The same faculty member from biology (a black male) and from computer science (a white male) taught the sections each fall.[4] Students were recruited at the end of the fall semester to participate in the study. For the biology course there was a response rate of 104/206 (50.5 percent) for the fall 2017 semester and 82/196 (41.8 percent) for the fall 2018 semester. For the computer science course the response rate was 61/182 (33.5 percent) for the fall 2017 semester and 60/202 (29.7 percent) for the fall 2018 semester.[5]

Surveys

I emailed students an invitation and a link to the online survey to participate in a post-course survey on perceptions of their experiences within STEM courses after they had received their final grades for the course. As an incentive, students who completed a survey and provided their information via a separate form were given a $5 Amazon gift certificate. Students indicated their consent before taking the online survey.

Independent Variables

Justice. Indicators for justice captured the three types of justice. To measure distributive justice (DJ) respondents were asked to evaluate their perception of the fairness of their grades on a seven-point scale (where 1 = strongly disagree and 7 = strongly agree). I distinguished between students' perception of the fairness of the actual grades themselves and students' sense of "earning" the grades they received. A 4-item scale that was averaged across items ($\alpha = .87$) measured students' sense of the fairness of their final grades, lab grades, quiz grades, and exam grades. The second was a 3-item scale averaged across items ($\alpha = .91$) measuring students' sense of what they did to earn the grades they received by evaluating whether they felt that their grades were fair "considering the responsibilities I had," "for the amount of effort I put forth," and "considering the stress I experienced."

Measures for procedural justice (PJ) focused on students' perceptions of the procedures faculty members use in making decisions about their performance in the classroom. Adapting items from Folger and Konovsky (1989), I asked respondents to indicate their disagreement or agreement with ten statements (see Table 2.2) regarding how their professors tap into different principles of procedural justice (e.g., consistency, voice, accuracy). Respondents indicated on a seven-point scale (where 1 = strongly disagree and 7 = strongly agree) the extent to which their professor had, for example: "used consistent standards in evaluating your performance," "gave me feedback that helped me learn how well I was doing," "took into account factors beyond my control," and "made clear what was expected of me." The procedural justice scale combined and averaged responses to the ten items ($\alpha = .87$).

[Table 2.2 about here]

Capturing fairness of treatment between students and faculty members, the interpersonal justice (IJ) scale derives items from Moorman (1991) (see Table 2.3). I asked respondents to indicate how much they agree (where 1 = strongly disagree and 7 = strongly agree) with questions such as: the extent to which their professor or other students "treats you without bias," "treats you with kindness and consideration," and "takes steps to deal with you in a truthful manner." The interpersonal justice items provided the basis for three different scales (with items added and averaged by the number in each scale) based on principal component exploratory factor analysis results. The first 2-item scale had a bivariate correlation of .85, and measured students' perception that their professors cared about the students' welfare; the second 6-item scale (α =.95) measured the perception that professors taught respectfully; and the third 3-item (α =.93) scale measured the perception that professors taught free from bias.

[Table 2.3 about here]

Perceptions of Interpersonal Justice by Peers. The survey asked students to assess on a seven-point scale (where 1 = strongly disagree and 7 = strongly agree) whether other students in the class seemed to: "respect me," "treat me as an equal," "treat me with kindness and consideration," "listen to my ideas," and "take into account my ideas on group projects." As well as the more interpersonal aspects of their interactions with their peers such as whether other students seemed to "be very concerned about my welfare," "provide help when I have a problem," and "treat me in an unbiased way." This scale involved averaging responses to the eight items (α =.96).

Status Characteristics. Students demographic characteristics indicate their diffuse status characteristics and include race, gender, and SES. I measure gender by a self-report of whether they identify as a man (0) or woman (1). To indicate race, I ask students' self-reported race as White/Caucasian, Black/African-American, Hispanic, Asian, or Native American. To test for an effect for students' race, I grouped respondents into three categories (white (0), black (1), and Asian (2)). I created a series of dummy variables to test for the effects of race, comparing white students to black students; white students compared to Asian students; and Asian students to black students. The results of these comparisons were largely not significant, so to simplify the models I used race as a white(0)/non-white(1) categorical variable. Data on income came from the respondents' reported parental income on a categorical scale (0=less than $25,000, 1=$25,001-$50,000, 2=$50,001 - $75,000, 3=$100,001 - $150,000, 4=$150,001 - $200,000, 5=$200,001 - $250,000, 6=More than $250,000).

Controls. I control for students' GPA, whether they were enrolled in introductory biology (0) or computer science (1), and the time at which they were enrolled (fall 2017 [T=0] or fall 2018 [T=1]).

Dependent Variables

Emotions. Students responded to the question: "how much did you typically feel each of the following [happy, excited, frustrated, encouraged, disappointed] about your biology or computer science class in general?" (where 1 = none at all and 7 = a great deal). Based on principle component factor analyses, I created two scales. The 3-item (α =.93) *positive emotion* scale averaged responses for happiness, excitement and encouraged and a 2-item (bivariate correlation = .87) *negative emotion* scale averaged responses for frustration and disappointment.

Competence. Competence was measured by averaging two items into a scale of students' self-reported assessments of their competence "I expect to do well in science courses" as well as their ability to learn, "I will be good at learning something new in science." The bivariate correlation for these items is .78.

Analysis

To examine the effects of justice and status processes on students' emotional and cognitive responses I utilized a series of OLS regressions (Fox 2015). Due to missing data, I imputed data on ordinal and interval-ratio variables using multiple imputation (M=2). The multivariate analysis examines the influence of perceived justice, status, and controls on emotions and competence. Below, I report the standardized coefficients for three models with positive emotions, negative emotions, and competence as the dependent variables. All regressions include control factors. Tests for multicollinearity for each model indicate low variance inflation factors (VIFs; 2.01 for all models, which is below the conventional 4.0 threshold) (O'Brien 2007). These results largely indicate multicollinearity was not present.

Results

My primary interest for this analysis is to examine how students' perceived experiences in the classroom shapes their reported emotions and assessment of competence. Table 2.4 presents the means, standard deviations, and bivariate correlations among all measures. As expected, results show that all forms of justice correlate positively with measures of positive emotions, and competence. Surprisingly, there was also a positive correlation between perceived justice and negative emotions. This relationship suggests that more experiences of justice are correlated with more frustration and disappointment. The bivariate relationship between gender (0=men, 1=women) and emotions and competence suggest that women, compared to men, report lower emotions of either type and lower competence. The bivariate relationship between race and course enrollment (0=biology, 1=computer science) and competence suggest that computer science students and nonwhites relative to biology students and whites, report lower perceptions of competence. In what follows, I present OLS results, first pertaining to positive and negative emotions followed by those pertaining to competence.

[Table 2.4 about here]

Emotions

Model 1 in Table 2.5 examines the effects of types of justice and status characteristics on positive emotions. Results largely confirm *Hypothesis 1*, predicting a positive relationship between perceived justice and positive emotions. There are significant positive effects for distributive justice (earned grades) ($\beta = .232$, $p < .001$), interpersonal justice represented as welfare ($\beta = .307$, $p < .001$), as free of bias ($\beta = .147$, $p < .05$), and in terms of perceived treatment by peers ($\beta = .169$, $p < .001$). These results suggest that students who perceive greater distributive and interpersonal justice, as well as a positive perception of how peers treat them (a form of interpersonal justice) report stronger positive emotions. Coefficient sizes represented in Model 1 also confirm *Hypothesis 2*, predicting a stronger effect for interpersonal and distributive justice compared to procedural justice ($\beta = .061$, $p > .05$) on students' emotions.

[Table 2.5 about here]

Model 2 in Table 2.5 examines the effects of types of justice and status characteristics on negative emotions. Results here provide minimal support for *Hypothesis 1*, predicting a negative relationship between justice and negative emotions. There was the predicted negative effect of distributive justice (grades) on negative emotions ($\beta = -.283$, $p < .001$). Yet, there was also an unexpected significant positive effect of distributive justice (earned grades) ($\beta = .458$, $p < .001$), suggesting that students who felt they had earned their grades experienced more negative emotions. No other form of justice exerted significant effects on negative emotions.

In contrast to results showing the impact of types of justice on emotions, there was only limited support for *Hypothesis 6*, predicting that males, white students, and students of higher SES are likely to experience more positive emotions and fewer negative emotions, emerged. The effects of gender and SES worked differently for positive and negative emotions. Consistent with *Hypothesis 6*, there was a negative effect of gender on positive emotions ($\beta = -.169$, $p < .001$), indicating as expected that women report experiencing less positive emotion in response to their STEM classes than do men. Also as suggested by *Hypothesis 6*, the negative effect of SES on negative emotions ($\beta = -.139$, $p < .01$) signals that lower SES students experienced more negative emotions than their higher SES counterparts. However, there were no statistically significant effects of race on students' positive or negative emotions.

Competence

Model 3 in Table 2.5 examines the effects of justice types and status characteristics on individuals' assessments of their perceived competence. Results provide some support for *Hypothesis* 3 predicting a positive relationship between justice and competence. Among the types of justice, distributive justice (earned grades) ($\beta = .268$, $p < .001$), and interpersonal justice (respect) ($\beta = .195$, $p < .05$) enhance perceived competence, indicating that it matters to students' perceptions of their competence that they earn fair grades and that their teacher treats them respectfully in their interactions. In addition, fairness in interactions with their peers positively shapes perceptions of competence ($\beta = .296$, $p < .001$). Yet, inconsistent with *Hypothesis 3*, interpersonal justice (free of bias) ($\beta = -.152$, $p < .05$) reduces students' perceived competence. Results confirm *Hypothesis* 4, predicting that the effect of distributive justice on competence would be strongest. The standardized coefficients suggest that distributive justice (earned grades) has the greatest effect on competence, compared to other forms of justice.

Results provide partial support for *Hypothesis 5*, predicting one's diffuse status characteristics (gender and race) are associated with perceptions of one's competence. The data indicate that gender ($\beta = -.232$, $p <.001$) and race ($\beta = -.122$, $p <.05$) are associated with competence, but show no significant effects of SES. As hypothesized, women perceive themselves to be less competent than men, and students of color perceived themselves to be less competent than white students.

Controls

Results for positive emotions indicate an effect of time ($\beta = -.153$, $p <.001$), suggesting that students in the Fall 2017 cohort reported having experienced significantly fewer positive emotions than the Fall 2018 cohort. For negative emotions there were significant effects for GPA ($\beta = .116$, $p < .05$), and course enrollment ($\beta = -.316$, $p < .001$). Students who had higher GPAs reported experiencing more negative emotions; similarly, students enrolled in computer science experienced more negative emotions. Not surprisingly, results for competence show positive effects of GPA ($\beta = .199$, $p < .001$), indicating that students with higher GPAs perceived themselves to be more competent.

Discussion

This study investigates how social psychological justice and status processes bear upon students' responses to their experiences in STEM courses within postsecondary education. With perceptions that fairness unfolds in their classrooms, students feel confident in their belonging to a social group that is important to them, which enhances their positive emotions, though has little impact on their negative ones. Similarly, students who feel fairly treated are likely to interpret this as a sign that they are seen by their professors and peers as a competent student. Diffuse status characteristics also play a minor role in generating emotions and a major one in shaping perceptions of competence. Patterns of results from this study suggest five main conclusions.

Importance of Justice Perceptions

First, perceptions of justice in the classroom, both in terms of the hierarchical relationship between instructors and students but also among students, matter for shaping students' emotional responses. As predicted in *Hypothesis 1*, there was a positive relationship between perceived justice and positive emotions. However, there were unexpected findings between justice and negative emotions, with a significant positive effect of distributive justice and negative emotions. That is, students who felt they had earned their grades experienced more negative emotions.

What this suggests, is that as students feel they have earned their grades through the amount of coursework they completed, the stress they experienced, and their efforts, they also experienced more frustration and disappointment. It is possible that this relationship indicates the stressful experience of many students in order to achieve a higher grade in a course, aligning with previous research on students' extreme affective distress during college due to their grades (Papanikolaou et al. 2003; Struthers et al. 2000).

The relationship between earned grades and negative emotions was somewhat consistent with *Hypothesis 2,* where grades that were perceived to be fair are associated students who felt they had earned their grades experienced more negative emotions. with fewer negative emotions, and in model 1, earned grades are also associated with increased positive emotions. However, in model 2, students who felt they had earned their grades experienced more negative emotions, and the effect of this coefficient was stronger than the effect of earned grades on students' positive emotions. While students experience positive emotions as a result of the higher grades, and as a result of feeling that they have earned their higher grades, students may also be frustrated and disappointed by the amount of work and stress that was required to achieve their desired grades. It is also possible that students felt entitled to preferential treatment or less rigid grading from their professors, or that the grading scheme was unfair and too challenging. Also as expected in *Hypothesis 2,* among the justice factors that matter most for both positive and negative emotional reactions, are considerations of distributive justice and interpersonal justice. For both positive and negative emotions, students' perceptions that grades are fairly distributed, are of paramount importance. As other work shows, grades have a significant effect on students' self-esteem, emotions, and self-worth (Crocker et al. 2003; Stupnisky et al. 2013), and provide students with an individualized evaluation of their classroom contributions.

For interpersonal justice, a large part of the college experience for many students is building connections with others, and ensuring their sense of belongingness in their social groups (Allen et al. 2008; Lee and Robbins 1995; Tellhed et al. 2017). To evaluate their standing and belongingness within a group, students rely on interpersonal justice as an indication of their value to the group (Lind and Tyler 1988). Although it can be difficult to ensure fair treatment from peers, faculty members can help to improve students' positive emotions by demonstrating that they care about their students, and treating students in a respectful way.

Lack of Effects of Procedural Justice

Second, the lack of findings in all models for procedural justice, and for interpersonal justice on negative emotions was surprising given past research. The justice literature has historically highlighted the importance of procedural justice within organizations. Previous research indicates for example, that employees who have a representative voice within an organization are less likely to exhibit turnover behavior and are more likely to be committed to the group (Allen, Shore, and Griffeth 2003; Aquino et al. 1997; Simons and Roberson 2003). Surprisingly, my results indicate that procedural justice does not significantly shape students' emotional responses to their experiences in the classroom. Previous research has indicated the lack of a procedural justice effect on positive emotions (Krehbiel and Cropanzano 2000) with more recent research highlighting procedural injustice's greater impact on negative affect (Barkworth and Murphy 2015).

Although it was expected that interpersonal and distributive justice would matter more compared to procedural justice, it was surprising that procedural justice was insignificant in all models. It is possible students did not have enough information or there was no variation in information about the rules and procedures of the course for procedural justice to have a significant impact on their emotions and perceptions of competence. Students do not expect to be able to make course decisions, or to have voice in the course (including the structure and day-to-day experiences of the course), which may account for why procedural justice hardly affected students' emotions and perceptions of their competence.

Compared to justice literature on organizations, it seems the structure of the relationship between authority and subordinates is distinct from that of instructor and students. My results suggest that the different nature of the relationship between students and teachers may mean it matters more to students to be able to see their professors as a mentor and ally that cares about them, above and beyond having fair procedures in place in the classroom. My results also suggest that it is important to check-in with students about their interpretations of the actions of faculty members, as it is students' perceptions of their treatment from faculty that matters, rather than simply the enactment of fair treatment. Professors should describe and model what constitutes appropriate and respectful interactions within the classroom to emphasize the equal and respectful treatment students should enact with their peers. Additionally, it is possible that professors were transparent about how grades would be assigned, and so there was not enough variation from the survey questions to tap into the relevant aspects of procedural justice that affected students' emotional responses to their experiences. Future research that can assess examples of what students *would* perceive to be issues of procedural justice and injustice and then tease out the importance of PJ in a college classroom.

Considering the strong interpersonal justice effects on students' positive emotions it is surprising that the relationship between interpersonal justice and negative emotions was not significant. That is, consistent with *Hypothesis 2*, students who experienced high interpersonal justice reported more positive emotions, but there was no significant effect for negative emotions. It is possible that the specific negative emotions measured for this study (frustration and disappointment) are not particularly affected by students' experiences of interpersonal justice. Future research should explore a wider range of negative emotions to further explore the effects of interpersonal justice on negative emotions.

Strong Effects of Distributive Justice and Interpersonal Justice

Third, consistent with *Hypothesis 3* perceptions of distributive justice in the classroom along with treatment from peers matter for shaping students' perceptions of their competence. Similarly, consistent with *Hypothesis 4* distributive justice mattered the most in shaping students' perceptions of their competence. Perceptions that students earned their grades matters the most, followed by being treated well by their peers for increasing students' perceptions of competence. My results suggest the importance of improving students' perceptions of the fairness of their grades and that they earned those grades to improve their competence, perhaps by signaling to students' an understanding of their efforts that went into the work they submit. Additionally, my results suggest the critical nature of teaching students respectfully, and creating situations in which students can interact positively with their peers (i.e., structured situations where peers can encourage and support the competent work of other students).

Role of Status Characteristics

Fourth, this study highlights the particular role that status characteristics play in making assumptions about the performance expectations, or the valuable contributions that individuals will make. My results support *Hypothesis 5,* and indicate the continuance of an ongoing trend within STEM that women and students of color perceive their competence as lower than men or white students do. Branching from Expectation States Theory, status characteristics theories and reward expectations describe how actors use status information in forming expectations of the contributions of others (Berger and Fişek 2006). Since task-relevant expertise cannot be directly observed, and groups are generally poor at integrating unshared information (Stasser 1999), members of a group must rely on ambiguous clues (often in the form of race or gender) to form assessments of an individual's expertise (Bunderson 2003).

Professors serve a vital role in helping students to incorporate the more relevant SSCs (task-relevant expertise) into their expectations of other students. Previous research has indicated the utility of a "transactive memory" (Bunderson 2003; Wegner, Erber, and Raymond 1991) approach to create shared knowledge of who knows what in a group (which may be emphasized by activities utilizing the jigsaw approach in the classroom to appoint students to certain roles either based on, or to help them develop their science talents). Professors who are able to highlight evidence of members' relative expertise can foster transactive memory in groups when these groups lack shared experiences to develop it on their own (Kozlowski and Bell 2012; Moreland and Myaskovsky 2000). In other words, professors who highlight the SSCs (perhaps in the form of sharing student responses from assignments) of students' abilities relevant to the course, will help students learn to overcome a reliance on race, gender, and class in making assessments of potential contributions to the group (Ridgeway 2011, 2014; Ridgeway et al. 1998).

Role of Emotions

Finally, consistent with previous literature (Kemper 1978, 1984, 1990) that stresses a strong relationship between emotions and position in the social structure, my results provide partial support for this pattern. My findings show that males are more likely to report experiencing positive emotions and lower SES students report experiencing greater negative emotions. Yet, no effects of race emerge, and gender and SES do not affect both types of emotions. The lack of effects for race may reflect what Ridgeway and Johnson (1990) argue may befall members of lower status groups: they feel constrained from expressing negative emotions which may result in self-reports that are more positive. In other words, students from lower status groups may also fear expressing negative emotions for fear of consequences (to their grades or standing within the department). Whether perceptions of such constraints reach the experience of emotions, such as those reported by study participants, remains for further investigation. Research that distinguishes between expressions and experiences of emotions in response to classroom dynamics may shed more light on the responses of women, URMs and lower SES students in STEM courses. It was surprising that there were not significant effects for race, yet even with multiple racial coding schemes, no effects of race emerged. Future research that addresses a wider range of emotions may help to better capture these status effects on emotions. Addressing a wider range of emotions could help distinguish variation in ways professors should emphasize their concerns for student welfare, and their availability to help students (via extra office hours, study sessions, available to give extra feedback, etc.) for students in lower status groups.

This study bring together results from both affective and cognitive responses to address how they might propel future behaviors, like continuation in STEM. Specifically, justice processes seem to shape students' emotions and perceptions of their competence, as do status processes to a lesser extent. Future research can assess the generalizability of these results by measuring students in different educational contexts in addition to students' experiences at one private university in the Southeast. This study also only measures a cross-sectional assessment of students' perceptions of their competence and emotions. A future longitudinal study could extend this research to help make causal determinations of the importance of changes in justice processes over the course of the semester by measuring students' perceptions of the justice and status processes in the classroom early in the semester, and again at the end of the semester. Future research would also benefit from surveying additional STEM departments to identify variation in the impact of justice and status processes across a wider variety of STEM departments.

Here I provide an initial analysis of how fairness and status processes shape positive and negative emotions and perceived competence, which offers mechanisms of interest to investigate student persistence within STEM. Future research conducting a follow-up with students to examine their persistence in their STEM majors over time may reveal more information about the long-term importance of experiencing justice in the classroom.

Despite the stressful presence of gatekeeper courses in many STEM disciplines, and the high uncertainty students face surrounding the long-term career implications of declaring an academic major, the importance of emotions in STEM courses are often overlooked. Through their emotional responses, students' experiences with justice may have consequences for their commitment to STEM fields, much like previous justice research in organizations shows that workplace fairness enhances individuals' organizational commitment (Brockner et al. 1990; Colquitt 2001; McFarlin and Sweeney 1992). Such a pattern dovetails with research that finds experiences with professors and students perceived to be fairer can create positive emotions (Stets 2005, 2006), encouraging persistence in STEM fields (e.g., Graham et al. 2013; Sabbagh and Resh 2016; Seymour and N. M. Hewitt 1997).

Implications for Policy and Practice

Overall, this study offers possible areas of intervention to help improve students' positive emotional reactions to their science courses, as well as areas that help them to perceive themselves as being more competent within science. My inclusion of emotions may help offices that cater to students exploring careers in STEM to counsel them on navigating their affective responses to experiences in STEM courses. My findings on the role of positive emotions can be used in conjunction with the importance of positive emotions on forming group ties (Lawler, Thye, and Yoon 2000, 2014) may play an especially strong role in encouraging student persistence within STEM majors, and offers suggestions support offices can build on. Moving forward, curriculums that encourage interactions in the classroom that display a concern for students' welfare, such as through informal means of checking in with students, may help to improve students' emotional reactions.

My research highlights the value in appreciating how students' classroom experiences may shape their decisions of a college major. My results suggest that to ensure students experience more positive than negative emotions during their experiences in STEM courses, faculty and departments train instructors to ensure interpersonal justice, and helping students to adjust the way they think about the importance of their grades. In addition, programs that help students to detach their perceived competence from their or others' personal status attributes, perhaps as suggested by some literature by offering role models of successful women and underrepresented minority scientists, may help women and URMs to have positive examples of scientists who are not only white men (Herrmann et al. 2016; Lockwood 2006). Schools that can offer concrete ways to help students make more positive associations with their STEM experiences may offer a useful pathway to encourage persistence in STEM.

Endnotes

[1] In the justice literature, distributive justice (Adams 1965; Deutsch 1985; Jost and Kay 2010), procedural justice (Leventhal et al. 1980; Thibaut and Walker 1975), and interpersonal justice (Bies 2001; Bies and Moag 1986) in some contexts are combined under one umbrella and assessed together as organizational justice. In this study I look at the effects of these types of justice individually.

[2] Some formulations of justice also include *informational* justice (Colquitt 2001) (indicating full and honest information about the procedures and distributions). While study participants responded to questions about informational justice, little variation emerged in the informational justice scale, perhaps accounting for why it was not statistically significant in any of the models. Thus, to simplify my argument, I exclude consideration of information justice.

[3] Although SES is generally not as visible as gender and race as a DSC, research demonstrates that it is still visible enough to influence interactions between students and their professors and peers (Johnson, Richeson, and Finkel 2011; Kraus, Piff, and Keltner 2011; Wald 2010).

[4] While I acknowledge that the instructor's race might influence students' reactions and experiences, it is not the focus of this study on classroom dynamics involving justice and status processes. Future research might examine the influence of an instructor's race and gender on those processes and students' affective and cognitive reactions.

[5] The computer science class had a large enrollment of international students for whom English was not their first language. For that reason, those students may have hesitated to complete a lengthy survey on their classroom experiences in English. In addition, the majority of these international students pay for their tuition without scholarships or aid, and thus, the $5 compensation offered may not have been enough to motivate them to respond to the survey.

Works Cited

Adams, J. Stacy. 1965. "Inequity in Social Exchange." *Advances in Experimental Social Psychology* 2:267–99.

Adamuti-Trache, Maria and Lesley Andres. 2008. "Embarking on and Persisting in Scientific Fields of Study: Cultural Capital, Gender, and Curriculum along the Science Pipeline." *International Journal of Science Education* 30(12):1557–84.

Allen, David G., Lynn M. Shore, and Rodger W. Griffeth. 2003. "The Role of Perceived Organizational Support and Supportive Human Resource Practices in the Turnover Process." *Journal of Management* 29(1):99–118.

Allen, Jeff, Steven B. Robbins, Alex Casillas, and In-Sue Oh. 2008. "Third-Year College Retention and Transfer: Effects of Academic Performance, Motivation, and Social Connectedness." *Research in Higher Education* 49(7):647–64.

Aquino, Karl, Rodger W. Griffeth, David G. Allen, and Peter W. Hom. 1997. "Integrating Justice Constructs into the Turnover Process: A Test of a Referent Cognitions Model." *Academy of Management Journal* 40(5):1208–27.

Areepattamannil, Shaljan, John G. Freeman, and Don A. Klinger. 2011. "Influence of Motivation, Self-Beliefs, and Instructional Practices on Science Achievement of Adolescents in Canada." *Social Psychology of Education* 14(2):233–59.

Banks, Joanne and Emer Smyth. 2015. "'Your Whole Life Depends on It': Academic Stress and High-Stakes Testing in Ireland." *Journal of Youth Studies* 18(5):598–616.

Barkworth, Julie M. and Kristina Murphy. 2015. "Procedural Justice Policing and Citizen Compliance Behaviour: The Importance of Emotion." *Psychology, Crime & Law* 21(3):254–73.

Barling, Julian and Michelle Phillips. 1993. "Interactional, Formal, and Distributive Justice in the Workplace: An Exploratory Study." *The Journal of Psychology* 127(6):649–56.

Berger, Joseph, B. P. Cohen, and M. Zelditch. 1972. "Status Characteristics and Social Interaction." *American Sociological Review* 37(3):241–255.

Berger, Joseph and Thomas L. Conner. 1974. "Performance Expectations and Behavior in Small Groups: A Revised Formulation." Pp. 85–110 in *Expectation states theory: A theoretical research program*, edited by J. Berger, T. Conner, and M. H. Fisek. Cambridge, Massachusetts: Winthrop.

Berger, Joseph and M. Hamit Fişek. 2006. "Diffuse Status Characteristics and the Spread of Status Value: A Formal Theory." *American Journal of Sociology* 111(4):1038–79.

Berger, Joseph, Cecilia L. Ridgeway, and Morris Zelditch. 2002. "Construction of Status and Referential Structures." *Sociological Theory* 20(2):157–79.

Berger, Joseph, Susan J. Rosenholtz, and Morris Zelditch Jr. 1980. "Status Organizing Processes." *Annual Review of Sociology* 6(1):479–508.

Berkowitz, Leonard. 1978. "Whatever Happened to the Frustration-Aggression Hypothesis?" *American Behavioral Scientist* 21(5):691–708.

Berkowitz, Leonard. 1989. "Frustration-Aggression Hypothesis: Examination and Reformulation." *Psychological Bulletin* 106(1):59.

Bies, Robert J. 2001. "Interactional (in)Justice: The Sacred and the Profane." Pp. 89–118 in *Advances in organizational justice*, edited by J. Greenberg and R. Cropanzano. Stanford, CA: Stanford University Press.

Bies, Robert J. and J. F. Moag. 1986. "Interactional Justice: Communication Criteria of Fairness." Pp. 43–55 in *Research on negotiation in organizations*. Vol. 1, edited by R. J. Lewicki, B. H. Sheppard, and M. H. Bazerman. Greenwich: Jai Press.

Bies, Robert J. and Thomas M. Tripp. 1996. “Beyond Distrust: ‘Getting Even’ and the Need for Revenge.” Pp. 246–60 in *Trust in organizations*, edited by R. M. Kramer and T. R. Tyler. Newbury Park, CA: Sage.

Bos, van den K., E. Allan Lind, and Henk A. M. Wilke. 2001. “The Psychology of Procedural and Distributive Justice Viewed from the Perspective of Fairness Heuristic Theory.” Pp. 49–66 in *Justice in the workplace: Volume 2. From theory to practice*, edited by R. Cropanzano. Mahwah, N.J.: Lawrence Erlbaum Associates.

Brockner, Joel, Rocki Lee DeWitt, Steven Grover, and Thomas Reed. 1990. “When It Is Especially Important to Explain Why: Factors Affecting the Relationship between Managers’ Explanations of a Layoff and Survivors’ Reactions to the Layoff.” *Journal of Experimental Social Psychology* 26(5):389–407.

Bunderson, J. Stuart. 2003. “Recognizing and Utilizing Expertise in Work Groups: A Status Characteristics Perspective.” *Administrative Science Quarterly* 48(4):557–91.

Chemers, Martin M., Li-tze Hu, and Ben F. Garcia. 2001. “Academic Self-Efficacy and First Year College Student Performance and Adjustment.” *Journal of Educational Psychology* 93(1):55.

Colquitt, Jason A. 2001. “On the Dimensionality of Organizational Justice: A Construct Validation of a Measure.” *Journal of Applied Psychology* 86(3):386.

Colquitt, Jason A., Donald E. Conlon, Lichael J. Wesson, C. O. L. H. Porter, and K. Yee Ng. 2001. “Justice at the Millenium: A Meta-Analytic Review of 25 Years of Organizational Justice Research.” *Journal of Applied Psychology* 86(3):425–45.

Crocker, Jennifer, Andrew Karpinski, Diane M. Quinn, and Sara K. Chase. 2003. “When Grades Determine Self-Worth: Consequences of Contingent Self-Worth for Male and Female

Engineering and Psychology Majors." *Journal of Personality and Social Psychology* 85(3):507.

Cropanzano, Russell, Jordan H. Stein, and Thierry Nadisic. 2011. *Social Justice and the Experience of Emotion*. New York: Routledge.

Deutsch, Morton. 1985. *Distributive Justice: A Social-Psychological Perspective*. New Haven, CT: Yale University Press.

Dollard, John, Neal E. Miller, Leonard W. Doob, Orval Hobart Mowrer, and Robert R. Sears. 1939. *Frustration and Aggression.* New Haven, CT: Yale University Press.

Eccles, Jacquelynne S. 1989. "Bringing Young Women to Math and Science." Pp. 36–58 in *Gender and thought: Psychological perspectives*, edited by M. Crawford and M. Gentry. New York: Springer-Verlag.

Fiske, Susan T. and Shelley E. Taylor. 2013. *Social Cognition: From Brains to Culture*. Thousand Oaks, California: Sage.

Folger, Robert, Tom R. Tyler, Robert J. Boeckmann, Heather J. Smith, and Yuen J. Huo. 2006. *Social Justice in a Diverse Society*. Vol. 44. Boulder, CO: Westview Press.

Foster, T. J., M. S. Foster, K. Flaugh, J. Kinschner, and N. Pidcock. 1994. An Empirical Test of Hall and Sandler's 1982 Report: Who Finds the Classroom Climate Chilly? Available online: https://eric.ed.gov/?id=ED373368 (accessed on 17 May 2018).

Fox, John. 2015. *Applied Regression Analysis and Generalized Linear Models*. Ontario: Sage Publications.

Graham, Mark J., Jennifer Frederick, Angela Byars-Winston, Anne-Barrie Hunter, and Jo Handelsman. 2013. "Increasing Persistence of College Students in STEM." *Science* 341(6153):1455–56.

Hegtvedt, Karen A. 2018. “Justice Frameworks.” Pp. 54–80 in *Contemporary Social Psychological Theories*, edited by P. J. Burke. Stanford, California: Stanford University Press.

Hegtvedt, Karen A. and Christie L. Parris. 2014. “Emotions in Justice Processes.” Pp. 103–25 in *Handbook of the Sociology of Emotions: Volume II*. New York: Springer.

Herrmann, Sarah D., Robert Mark Adelman, Jessica E. Bodford, Oliver Graudejus, Morris A. Okun, and Virginia S. Y. Kwan. 2016. “The Effects of a Female Role Model on Academic Performance and Persistence of Women in STEM Courses.” *Basic and Applied Social Psychology* 38(5):258–68.

Holland, J. L. 1997. *Making Vocational Choices: A Theory of Vocational Personalities and Work Environments*. Vol. 3. 3rd ed. Odessa, FL: Psychological Assessment Resources.

Homans, George C. 1974. *Social Behavior: Its Elementary Forms*. New York: Harcourt, Brace & World.

Johnson, Sarah E., Jennifer A. Richeson, and Eli J. Finkel. 2011. “Middle Class and Marginal? Socioeconomic Status, Stigma, and Self-Regulation at an Elite University.” *Journal of Personality and Social Psychology* 100(5):838.

Jost, John T. and Aaron C. Kay. 2010. “Social Justice: History, Theory, and Research.” Pp. 1122–65 in *Handbook of Social Psychology*, edited by S. T. Fiske, D. T. Gilbert, and G. Lindzey. Hoboken: John Wiley & Sons.

Kelley, Harold H. 1967. “Attribution Theory in Social Psychology.” Pp. 192–238 in *Nebraska symposium on motivation*. Lincoln: University of Nebraska Press.

Kemper, Theodore D. 1978. “Toward a Sociology of Emotions: Some Problems and Some Solutions.” *The American Sociologist* 13(2):30–41.

Kemper, Theodore D. 1984. “Power, Status, and Emotions: A Sociological Contribution to a Psychophysiological Domain.” Pp. 377–78 in *Approaches to emotion*, edited by K. . Scherer and P. Ekman. Hillsdale, NJ: Erlbaum.

Kemper, Theodore D. 1987. “How Many Emotions Are There? Wedding the Social and the Autonomic Components.” *American Journal of Sociology* 93:263–89.

Kemper, Theodore D. 1990. “Social Relations and Emotions: A Structural Approach.” Pp. 207–37 in *Research agendas in the sociology of emotions*, edited by T. D. Kemper. Albany, NY: SUNY Press.

Kozlowski, Steve W. J. and Bradford S. Bell. 2012. “Work Groups and Teams in Organizations.” Pp. 333–75 in *Handbook of Psychology: Industrial and organizational psychology*. Vol. 12, edited by W. . Borman and D. R. Ilgen. New York: Wiley Online Library.

Kraus, Michael W., Paul K. Piff, and Dacher Keltner. 2011. “Social Class as Culture: The Convergence of Resources and Rank in the Social Realm.” *Current Directions in Psychological Science* 20(4):246–50.

Krehbiel, Patricia J. and Russell Cropanzano. 2000. “Procedural Justice, Outcome Favorability and Emotion.” *Social Justice Research* 13(4):339–60.

Kurdoglu, Rasim Serdar. 2019. “The Mirage of Procedural Justice and the Primacy of Interactional Justice in Organizations.” *Journal of Business Ethics* 1–18.

Lawler, Edward J. and Shane R. Thye. 2006. “Social Exchange Theory of Emotions.” Pp. 295–320 in *Handbook of the Sociology of Emotions*, edited by J. H. Turner and J. E. Stets. New York: Springer.

Lawler, Edward J., Shane R. Thye, and Jeongkoo Yoon. 2000. “Emotion and Group Cohesion in

Productive Exchange." *American Journal of Sociology* 106(3):616–57.

Lawler, Edward J., Shane R. Thye, and Jeongkoo Yoon. 2014. "Emotions and Group Ties in Social Exchange." Pp. 77–101 in *Handbook of the Sociology of Emotions: Volume II*, edited by J. E. Stets and J. H. Turner. New York: Springer.

Lee, Richard M. and Steven B. Robbins. 1995. "Measuring Belongingness: The Social Connectedness and the Social Assurance Scales." *Journal of Counseling Psychology* 42(2):232.

Lent, Robert W., Steven D. Brown, Hung-Bin Sheu, Janet Schmidt, Bradley R. Brenner, Clay S. Gloster, Gregory Wilkins, Linda C. Schmidt, Heather Lyons, and Dana Treistman. 2005. "Social Cognitive Predictors of Academic Interests and Goals in Engineering: Utility for Women and Students at Historically Black Universities." *Journal of Counseling Psychology* 52(1):84.

Leventhal, Gerald S. 1976. *Fairness in Social Relationships*. Morristown, NJ: General Learning Press.

Leventhal, Gerald S., Jurgis Karuza, and William R. Fry. 1980. "Beyond Fairness: A Theory of Allocation Preferences." *Justice and Social Interaction* 3(1):167–218.

Lind, E. Allan and T. R. Tyler. 1992. "A Relational Model of Authority in Groups." *Advances in Experimental Social Psychology* 25:115–92.

Lind, E. Allan and Tom R. Tyler. 1988. *The Social Psychology of Procedural Justice*. New York: Plenum.

Lockwood, Penelope. 2006. "'Someone like Me Can Be Successful': Do College Students Need Same-Gender Role Models?" *Psychology of Women Quarterly* 30(1):36–46.

Lovaglia, Michael J. and Jeffrey A. Houser. 1996. "Emotional Reactions and Status in Groups."

American Sociological Review 96:867–83.

Maltese, Adam V and Robert H. Tai. 2011. “Pipeline Persistence: Examining the Association of Educational Experiences with Earned Degrees in STEM among US Students.” *Science Education* 95(5):877–907.

McFarlin, Dean B. and Paul D. Sweeney. 1992. “Distributive and Procedural Justice as Predictors of Satisfaction with Personal and Organizational Outcomes.” *Academy of Management Journal* 35(3):626–37.

Miller, Kathleen E. 2008. “Energy Drinks, Race, and Problem Behaviors among College Students.” *Journal of Adolescent Health* 43(5):490–97.

Monforti, Jessica Lavariega and Melissa R. Michelson. 2008. “Diagnosing the Leaky Pipeline: Continuing Barriers to the Retention of Latinas and Latinos in Political Science.” *PS: Political Science & Politics* 41(01):161–66.

Moorman, Robert H. 1991. “Relationship between Organizational Justice and Organizational Citizenship Behaviors: Do Fairness Perceptions Influence Employee Citizenship?” *Journal of Applied Psychology* 76(6):845.

Moreland, Richard L. and Larissa Myaskovsky. 2000. “Exploring the Performance Benefits of Group Training: Transactive Memory or Improved Communication?” *Organizational Behavior and Human Decision Processes* 82(1):117–33.

Morris, L. K. 2003. “The chilly climate for women: A literature review.” Presented at the Annual Meeting of the Mid-South Educational Research Association, November, Biloxi, MI. Retrieved from ERIC database. (ED482555)

National Science Board. 2016. *Science and Engineering Indicators 2016 NSF - National Science Foundation*.

O'brien, Robert M. 2007. "A Caution Regarding Rules of Thumb for Variance Inflation Factors." *Quality & Quantity* 41(5):673–90.

Oakes, Jeannie. 1990. *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science.* Santa Monica, CA: The RAND Corporation.

Papanikolaou, Z., D. Nikolaidis, A. Patsiaouras, and P. Alexopoulos. 2003. "The Freshman Experience: High Stress-Low Grades." *Athletic Insight: The On-Line Journal of Sport Psychology* 5(4):1–8.

Ratelle, Catherine F., Simon Larose, Frédéric Guay, and Caroline Senécal. 2005. "Perceptions of Parental Involvement and Support as Predictors of College Students' Persistence in a Science Curriculum." *Journal of Family Psychology* 19(2):286.

Redmond-Sanogo, Adrienne, Julie Angle, and Evan Davis. 2016. "Kinks in the STEM Pipeline: Tracking STEM Graduation Rates Using Science and Mathematics Performance." *School Science and Mathematics* 116(7):378–88.

Ridgeway, Cecilia and Cathryn Johnson. 1990. "What Is the Relationship between Socioemotional Behavior and Status in Task Groups?" *American Journal of Sociology* 95(5):1189–1212.

Ridgeway, Cecilia L. 2006. "Status Construction Theory." Pp. 301–23 in, edited by P. J. Burke. Stanford, California: Stanford University Press.

Ridgeway, Cecilia L. 2011. *Framed by Gender: How Gender Inequality Persists in the Modern World*. New York: Oxford University Press.

Ridgeway, Cecilia L. 2014. "Why Status Matters for Inequality." *American Sociological Review* 79(1):1–16.

Ridgeway, Cecilia L., Elizabeth Heger Boyle, Kathy J. Kuipers, and Dawn T. Robinson. 1998. "How Do Status Beliefs Develop? The Role of Resources and Interactional Experience." *American Sociological Review* 63(3):331–50.

Ridgeway, Cecilia L. and Henry A. Walker. 1995. "Status Structures." Pp. 281–310 in *Sociological perspectives on social psychology*, edited by K. S. Cook, G. A. Fine, and J. S. House. New York: Allyn and Bacon.

Rine, P. Jesse. 2014. *Strengthening the STEM Pipeline: The Contributions of Small and Mid-Sized Independent Colleges.* Washington D.C.: Council of Independent Colleges.

Sabbagh, Clara and Nura Resh. 2016. "Unfolding Justice Research in the Realm of Education." *Social Justice Research* 29(1):1–13.

Schuster, Carolin and Sarah E. Martiny. 2017. "Not Feeling Good in STEM: Effects of Stereotype Activation and Anticipated Affect on Women's Career Aspirations." *Sex Roles* 76(1–2):40–55.

Seymour, Elaine and Nancy M. Hewitt. 1997. *Talking About Leaving: Why Undergraduates Leave the Sciences.* Oxford: Westview Press.

Shapiro, Jenessa R. and Amy M. Williams. 2012. "The Role of Stereotype Threats in Undermining Girls' and Women's Performance and Interest in STEM Fields." *Sex Roles* 66(3–4):175–83.

Shim, Sungok and Allison Ryan. 2005. "Changes in Self-Efficacy, Challenge Avoidance, and Intrinsic Value in Response to Grades: The Role of Achievement Goals." *The Journal of Experimental Education* 73(4):333–49.

Simon, Richard M., Ashley Wagner, and Brooke Killion. 2017. "Gender and Choosing a STEM Major in College: Femininity, Masculinity, Chilly Climate, and Occupational Values."

Journal of Research in Science Teaching 54(3):299–323.

Simons, Tony and Quinetta Roberson. 2003. "Why Managers Should Care about Fairness: The Effects of Aggregate Justice Perceptions on Organizational Outcomes." *Journal of Applied Psychology* 88(3):432.

Sjøberg, Svein and Camilla Schreiner. 2005. "How Do Learners in Different Cultures Relate to Science and Technology? Results and Perspectives from the Project ROSE (The Relevance of Science Education)." *Asia-Pacific Forum on Science Learning and Teaching* 6(2):1–17.

Stasser, Garold. 1999. "The Uncertain Role of Unshared Information in Collective Choice." Pp. 49–69 in *Shared cognition in organizations: The management of knowledge*, edited by L. . Thompson, J. M. Levine, and D. M. Messick. Mahwah, N.J.: Erlbaum.

Stecher, Mary D. and Joseph G. Rosse. 2005. "The Distributive Side of Interactional Justice: The Effects of Interpersonal Treatment on Emotional Arousal." *Journal of Managerial Issues* 17:229–46.

Stets, Jan E. 2005. "Examining Emotions in Identity Theory." *Social Psychology Quarterly* 68(1):39–56.

Stets, Jan E. 2006. "Identity Theory and Emotions." Pp. 203–23 in *Handbook of the Sociology of Emotions*, edited by J. E. Stets and J. H. Turner. New York: Springer.

Struthers, C. Ward, Raymond P. Perry, and Verena H. Menec. 2000. "An Examination of the Relationship among Academic Stress, Coping, Motivation, and Performance in College." *Research in Higher Education* 41(5):581–92.

Stupnisky, Robert H., Raymond P. Perry, Robert D. Renaud, and Steve Hladkyj. 2013. "Looking beyond Grades: Comparing Self-Esteem and Perceived Academic Control as Predictors of First-Year College Students' Well-Being." *Learning and Individual Differences* 23:151–57.

Sun, Letao, Kelly D. Bradley, and Kathryn Akers. 2012. “A Multilevel Modelling Approach to Investigating Factors Impacting Science Achievement for Secondary School Students: PISA Hong Kong Sample.” *International Journal of Science Education* 34(14):2107–25.

Tellhed, Una, Martin Bäckström, and Fredrik Björklund. 2017. “Will I Fit in and Do Well? The Importance of Social Belongingness and Self-Efficacy for Explaining Gender Differences in Interest in STEM and HEED Majors.” *Sex Roles* 77(1–2):86–96.

Thibaut, John W. and Laurens Walker. 1975. *Procedural Justice: A Psychological Analysis*. Hillsdale, NJ: L. Erlbaum Associates.

Tobias, Sheila. 1990. “Stemming the Science Shortfall at College.” in *They’re not dumb, they’re different*, edited by S. Tobias. Tucson, AZ: Research Corporation.

Tobias, Sheila. 1992. “Science Education Reform What’s Wrong with the Process?” *Change: The Magazine of Higher Learning* 24(3):12–19.

Trockel, Mickey T., Michael D. Barnes, and Dennis L. Egget. 2000. “Health-Related Variables and Academic Performance among First-Year College Students: Implications for Sleep and Other Behaviors.” *Journal of American College Health* 49(3):125–31.

Trujillo, Gloriana and Kimberly D. Tanner. 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.

Turner, Jonathan H. and Jan E. Stets. 2005. *The Sociology of Emotions*. Cambridge, Massachusetts: Cambridge University Press.

Tyler, Tom R. and Steven L. Blader. 2000. *Cooperation in Groups: Procedural Justice, Social Identity, and Behavioral Engagement*. Philadelphia: Psychology Press.

Valkenburg, M. E. Van. 1990. “An Engineering Curriculum for the Future.” *IEEE*

Communications Magazine 28(12):12–15.

Wald, Eli. 2010. “The Visibility of Socioeconomic Status and Class-Based Affirmative Action: A Reply to Professor Sander.” *Denv. UL Rev.* 88:861.

Walker, Christopher O., Barbara A. Greene, and Robert A. Mansell. 2006. “Identification with Academics, Intrinsic/Extrinsic Motivation, and Self-Efficacy as Predictors of Cognitive Engagement.” *Learning and Individual Differences* 16(1):1–12.

Watt, Helen M. G. and Jacquelynne S. Eccles. 2008. *Gender and Occupational Outcomes: Longitudinal Assessments of Individual, Social, and Cultural Influences.* Washington D.C.: American Psychological Association.

Webster, Murray Jr. and Martha Foschi. 1988. “Overview of Status Generalization.” Pp. 1–20 in *Status Generalization: New Theory and Research*, edited by M. J. Webster and M. Foschi. Stanford, California: Stanford University Press.

Wegner, Daniel M., Ralph Erber, and Paula Raymond. 1991. “Transactive Memory in Close Relationships.” *Journal of Personality and Social Psychology* 61(6):923.

Weiner, Bernard, Richard Nierenberg, and Mark Goldstein. 1976. “Social Learning (Locus of Control) versus Attributional (Causal Stability) Interpretations of Expectancy of Success.” *Journal of Personality* 44:52–68.

Willer, David, Michael J. Lovaglia, and Barry Markovsky. 1997. “Power and Influence: A Theoretical Bridge.” *Social Forces* 76(2):571–603.

Xie, Yu, Michael Fang, and Kimberlee Shauman. 2015. “Stem Education.” *Annual Review of Sociology* 41:331–57.

Table 2.1. Percentages of Students Enrolled in Computer Science or Biology Courses at the Private University in 2018-19

All enrolled Students			Students by Major In total numbers	
Ethnicity	**CS %**	**Bio %**	**CS**	**Bio**
Total	100%	**100%**	**38**	**338**
Am. Indian	0.0%	0.1%	0	0
Asian	25.9%	33.6%	10	116
Black	3.5%	8.0%	1	25
Hispanic	5.8%	10.6%	1	36
Multi	3.2%	4.1%	1	21
Non US Citizen	39.5%	10.9%	15	39
Unknown	0.0%	1.3%	1	6
White	22.1%	31.4%	9	95
Gender				
Female	38.9%	60.6%	8	212
Male	61.1%	39.4%	30	126

Table 2.2. Items used in the Procedural Justice Scale

In your Fall 2018 biology or computer science course, please think about your professor and indicate how much you disagree or agree with the following statements as they characterized your interactions throughout the semester. My professor seemed to... (1 = strongly disagree, 7 = strongly agree)	1. use consistent standards in evaluating my performance 2. give me feedback that helped me learn how well I was doing 3. take into account factors beyond my control 4. discuss plans or objectives to improve my performance 5. obtain accurate information about my performance 6. make clear what was expected of me 7. provide timely information about course decisions and their implications 8. be influenced by things that should not be considered 9. give opportunities to express any concerns 10. appear to allow his/her personal motives or biases to influence evaluation

Table 2.3. Items used in the Interpersonal Justice Scale

Interpersonal Justice - Professor (Respect) In your Fall 2018 biology or computer science course, please think about your professor and indicate how much you disagree or agree with the following statements as they characterized your interactions throughout the semester. My professor seemed to... (1= strongly disagree, 7 = strongly agree)	1. ….respect students 2. … take steps to deal with me in a truthful manner 3. … treat me with kindness and consideration 4. … be honest and ethical in dealing with me 5. … be completely candid and frank with me 6. show a real interest in trying to be fair
Interpersonal Justice - Professor (Free from bias) In your Fall 2018 biology or computer science course, please think about your professor and indicate how much you disagree or agree with the following statements as they characterized your interactions throughout the semester. My professor seemed to... (1= strongly disagree, 7 = strongly agree)	1. treat students of all genders equally 2. treat students of all races equally 3. refrain from improper remarks or comments
Interpersonal Justice – Peers In the next section, think about your interactions with other students in your Fall 2018 biology or computer science course. Other students in my class seemed to... (1= strongly disagree, 7 = strongly agree)	1. … respect me 2. … treat me as an equal 3. … treat me with kindness and consideration 4. … listen to my ideas 5. … take into account my ideas on group projects 6. … be very concerned about my welfare 7. … provide help when I have a problem 8. … treat me in an unbiased way

Table 2.4. Correlation Matrix with Means (and Standard Deviations) on the Diagonal (n= 331)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
(1) Competence	5.59(1.17)															
(2) Pos Emotions	0.308*	4.21(1.77)														
	0.00															
(3) Neg Emotions	0.228*	0.396*	4.14 (1.74)													
	0.00	0.00														
(4) Grades	0.324*	0.447*	0.305*	5.39(1.38)												
	0.00	0.00	0.00													
(5) Earned Grades	0.369*	0.537*	0.408*	0.794*	5.11(1.58)											
	0.00	0.00	0.00	0.00												
(6) PJ	0.227*	0.521*	0.215*	0.538*	0.531*	5.17(1.10)										
	0.00	0.00	0.00	0.00	0.00											
(7) IJ Welfare	0.182*	0.560*	0.261*	0.450*	0.424*	0.754*	5.05(1.64)									
	0.01	0.00	0.00	0.00	0.00	0.00										
(8) IJ Respect	0.268*	0.420*	0.229*	0.488*	0.417*	0.647*	0.711*	6.06(.99)								
	0.00	0.00	0.00	0.00	0.00	0.00	0.00									
(9) IJ Free Bias	0.151*	0.261*	0.206*	0.335*	0.281*	0.455*	0.503*	0.749*	6.29(.98)							
	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00								
(10) Peer Treatment	0.339*	0.341*	0.180*	0.297*	0.326*	0.317*	0.327*	0.334*	0.381*	5.63(1.05)						
	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00							
(11) GPA	0.280*	0.08	0.177*	0.227*	0.248*	0.01	0.04	0.00	-0.10	0.10	3.54(.4)					
	0.00	0.29	0.01	0.00	0.00	0.89	0.58	0.97	0.18	0.18						
(12) Women	-0.170*	-0.161*	-0.06	-0.03	-0.12	-0.01	0.00	0.02	0.06	0.06	0.11	.64(.48)				
	0.02	0.02	0.40	0.67	0.10	0.92	0.98	0.79	0.40	0.39	0.12					
(13) SES	0.07	-0.08	-0.10	-0.03	-0.04	-0.05	-0.01	-0.01	0.00	-0.01	0.219*	-0.02	3.63(1.97)			
	0.33	0.25	0.16	0.63	0.58	0.48	0.93	0.93	0.95	0.95	0.00	0.83				
(14) Non-White	-0.171*	0.10	0.04	-0.01	0.07	0.177*	0.148*	0.03	-0.03	0.05	-0.01	0.04	-0.214*	.58(.49)		
	0.01	0.15	0.58	0.87	0.35	0.01	0.04	0.65	0.67	0.51	0.93	0.57	0.00			
(15) Enrollment CS	-0.08	0.00	-0.178*	-0.202*	-0.11	-0.139*	-0.141*	-0.11	-0.06	-0.13	-0.03	-0.185*	-0.03	-0.04	.38(.49)	
	0.28	0.95	0.01	0.00	0.10	0.05	0.04	0.10	0.40	0.06	0.66	0.01	0.72	0.62		
(16) Time	0.02	0.00	-0.01	0.07	0.06	0.09	0.09	0.08	0.04	0.03	-0.02	-0.10	-0.04	0.01	0.04	.45(
	0.83	0.99	0.93	0.29	0.38	0.18	0.21	0.22	0.54	0.71	0.83	0.17	0.57	0.89	0.58	

* shows significance at the .05 level

Table 2.5. Ordinary Least Squares Standardized Regression Coefficients (standard errors) for Effects of Justice Processes and Status Processes on Positive Emotions, Negative Emotions, and Competence

	Model 1			**Model 2**			**Model 3**		
	Positive Emotions			***Negative Emotions***			***Competence***		
IVs	Beta		Std. Err.	Beta		Std. Err.	Beta		Std. Err.
Grades	0.074		0.09	-0.283	***	0.11	0.035		0.06
Earned Grades	0.232	***	0.08	0.458	***	0.09	0.268	***	0.05
Procedural Justice	0.061		0.12	-0.126		0.14	0.068		0.08
IJ Welfare	0.307	***	0.08	0.139		0.10	-0.133		0.06
IJ Respect	0.132		0.15	-0.045		0.18	0.195	*	0.10
IJ Free bias	-0.147	*	0.12	0.094		0.14	-0.152	*	0.08
Peer Treatment	0.030		0.08	-0.005		0.10	0.296	***	0.06
Women	-0.169	***	0.17	-0.020		0.21	-0.232	***	0.12
SES	0.043		0.04	-0.139	**	0.05	-0.061		0.03
Nonwhite	0.006		0.16	-0.096		0.19	-0.122	*	0.11
GPA	0.069		0.19	0.116	*	0.23	0.199	***	0.13
Enrollment CS	0.026		0.17	-0.316	***	0.20	-0.029		0.11
Time	-0.153	***	0.15	-0.014		0.18	-0.011		0.10
_cons	.		0.94	.		1.13	.		0.63
R^2 (adjusted)	0.3683			0.1879			0.3511		

Notes: N=331. *p<.05 **p<.01 ***p<.001 (two-tailed test)

Chapter 3: The College Classroom Experience and it's influences on Science Identities and Persistence

Introduction

Despite increased attention, research, and interventions to reduce disparities in educational outcomes by gender, race, and class, there has been uneven progress—especially in Science, Technology, Engineering, and Math (STEM) fields. Research on the retention of students in STEM emphasize traditional individual-based approaches stressing students' individual level interests and aspirations, as well as family and contextual factors, such as their residential neighborhood and school (Xie, Fang, and Shauman 2015) to explain disparities in STEM postsecondary fields (Cech et al. 2011; Riegle-Crumb et al. 2012; Soh et al. 2007; Ulriksen et al. 2010). However, research focusing on individual cognitive ability, spatial ability, numeracy, or other indicators correlated with achievement in math and science (Spelke 2005) fails to address findings indicating that students who switch majors (and leave STEM) and non-switchers are very similar in their preparation to succeed (GPA, test scores, previous experience) and interest in science (Seymour and N. M. Hewitt 1997; Ulriksen et al. 2010).

For instance, despite women outpacing men in college academic performance (measured by GPA), enrollment numbers, and higher graduation rates (DiPrete and Buchmann 2013; Ewert 2010), large inequalities still remain in the career fields chosen by men and women. The underrepresentation of women and underrepresented minorities (URMs) in science occupations is also often explained by their greater likelihood to leave or be pushed out of STEM fields at every junction (Seymour and N. Hewitt 1997). Additionally, the much higher attrition rate of URMs from college in all majors makes finding solutions for the STEM attrition of URMs especially challenging (Riegle-Crumb and King 2010), as it suggests the existence of additional problems in higher education. Most research focuses on helping students to overcome deficits in their prior knowledge (Ulriksen et al. 2010), but the lack of significant differences in achievement between men and women, and whites and URM students in STEM suggests that the link between academic achievement (students' overall GPA) and choosing a STEM major may be more complicated. The traditional focus on individual student preparation and cognitive ability fails to explain the continuing disparities among women and underrepresented minorities.

Despite the array of studies that focus on academic achievement to explain STEM retention, few consider social psychological determinants (e.g., Maltese and Tai 2011; Tai et al. 2006). Among social psychological processes, those pertaining to identity are relevant, yet few studies considering science identity draw specifically on the theoretical mechanisms offered by the symbolic interaction tradition regarding forming science identities, especially in the field of science education (Ulriksen et al. 2010). Identities or self-definitions represent the various meanings attached to oneself by self and by others (Gecas and Burke 1995). Theories of identity are a useful lens to draw attention to the particular nature of STEM fields that makes it challenging for students other than those who identify as white and male to be included (Marlone and Barabino 2009). Much research addresses the types of people who progress into later careers in STEM disciplines (Heaverlo 2011; Lee 1998; Robnett 2013; Shapiro and Williams 2012) but do not address the ways a "science identity" specifically influences persistence. The few studies that do consider the importance of identities in science education are based on small qualitative samples and only focus on cognitive aspects of students experiences (Carlone and Johnson 2007). Thus, I augment Carlone and Johnson's (2007) qualitative development of a cognitive framework based on identity work by Gee (2000) by quantitatively analyzing factors that shape students' science identities.

Moving beyond the cognitive factors of competence, recognition, and performance noted by Carole and Johnson (2007), I also emphasize how students' positive and negative emotional responses to their classroom experience shapes their science identity. Thus, I examine how cognitive and affective responses to classroom experiences together contribute to a student's science identity—defined here as the sense that science is "right" for an individual or that an individual is "right" for science (Cole and Espinoza 2008; Correll 2001; Perez et al. 2014)—and whether that science identity signals persistence in STEM, as modeled in Figure 3.1.

[Figure 3.1 about here]

To investigate how students' assessments of their classroom experiences shape their perceptions of their science identity, and how these identities may influence persistence, I use survey data collected from biology and computer science students (n=786) at a private university over the course of two fall (2017, 2018) semesters. I begin by describing research on identity and identity processes, and then link this to empirical research in STEM fields on identity, emphasizing the less explored mechanisms that explain identity development. I then discuss how educational work has previously utilized the concept of identities in the form of Carlone and Johnson's (2007) model emphasizing competence, performance, and recognition, without elaborating on the underlying mechanisms within symbolic interactionism. Finally, I detail how identity theories call for the inclusion of positive and negative emotions in the process of identity development.

Findings from the analysis of responses to my surveys indicate that students' perceptions of their competence (and not their GPA) along with the received recognition (akin to the concept of verification from the symbolic interactionist framework) for their work shapes the degree to which students see themselves as scientists, and that students' science identity (and, unexpectedly, along with their negative emotions) cultivate students' intentions to enroll in future STEM courses. I argue research should expand the current focus on individual achievement and preparation processes (like overcoming deficits in prior knowledge) to understand how students' experience of the socialization process in the classroom impacts their ability to identify with and integrate into STEM fields, especially as such integration may depend on students' gender and race.

Identity and Identity Processes

Identities embed people in social structures that serve as their basis of interaction with others (Stryker 1980). An individual has an identity or an "internalized positional designation" for each different position or role that he or she holds in society (Stryker 1980). Gender, race, and class are only three of the many identities young adults bring into the classroom. People have many identities constituting the self, as many as the number of separate organized groups in which they participate. Additionally, identities are relational, and the meanings associated with certain roles are tied to other roles (e.g., what it means to be a teacher is tied to what it means to be a student), and each person not only knows his or her own meanings and expectations, but also those of others in related positions (Stets and Burke 2009). For example, a "scientist" carries specific behavioral expectations such as: working in a lab or engaging in research, working in an academic or industry institution, or someone who produces scientific knowledge. In this section, I begin by describing the STEM literature that addresses identity and then I relate this work to the basic social psychological theoretical processes omitted in this work that draw on symbolic interactionism and identity development generally.

STEM and Identity

Previous research has shown the importance of students' science and math self-concepts (Xie et al. 2015), interest in science (Mau 2003; Stage and Maple 1996; Xie and Shauman 2003), and aspirations to pursuing a science-related career. Science and math self-concepts refer to actors' self-reflexive beliefs about their science and math abilities. These self-concepts help to predict participation in STEM courses, persistence and attainment of STEM degrees, and entrance into STEM careers (Cech et al. 2011; Correll 2001; Maltese and Tai 2011; Mau 2003; Wang 2013; Xie et al. 2015). Conceptualizing one's interest in science as an identity is useful to allow questions about the types of people promoted or marginalized by science teaching and learning practices (Carlone and Johnson 2007), which fuel differences by gender and race in educational pursuits.

The college years occur during a critical point of identity development, as students move more concretely into adulthood and must solidify future identities related to their career paths. Indeed, for STEM students, the college level is the time students begin to specialize into disciplinary tracks, with only a small fraction choosing STEM fields (Xie and Killewald 2012; Xie and Shauman 2003). Students spend more time in school than any other setting, which has made education and the effects of school characteristics on achievement and identity formation a long-standing interest for researchers (Coleman 1968). Previous STEM research on identities explore the importance of a sense of belonging in STEM fields where the culture is largely white and masculine (Cheryan et al. 2017), and how this shapes decisions to major in STEM (Lee and Robbins 1995; Rainey et al. 2018; Tellhed et al. 2017). These researchers, however, typically use the declaration of major as a proxy for identity. Additionally, previous research on STEM identities highlights the important nature of students' other identities and the relationships among identities both on how students feel that they "fit" or belong in a STEM field, and how this affects their future decisions to major in STEM. In this study I do not look at the relationships among identities, like previous research that explores the effects of a gender identity or a racial identity on students' STEM interests (Horvat and Lewis 2003; Morton and Parsons 2018). Instead, I focus on the relatively unexplored processes of regarding how students develop and solidify their science identity in the higher education context, and the factors that contribute to a strong science identity. I draw from the theoretical mechanisms offered by symbolic interactionists who developed theories of identity processes.

Symbolic Interactionist theoretical mechanisms

Students' identities are constructed on the basis of the positions and roles in which they interact with others. A key focus of research on science identities centers on the disconnect between the broader cultural definitions of what it means to be a "scientist," "mathematician," or "engineer," and how a person sees him or herself. To the degree that students have a choice in the identities they come to assume, most are likely to take on identities related to their interests, which then guide students' behaviors to fit with those identities. Discrepancies between self-concepts and perceptions of disciplines are associated with lower interest in those disciplines (Lee 1998). Therefore, because science identities are often seen as masculine, and careers associated with them as predominantly white and male, these images pose difficulties for women and URMs who consider STEM fields (Lee 1998). To maintain their identity, girls may distance themselves from the stereotypical perception of masculine science students (Lee 1998). Similarly, social and cultural pressures surrounding racial identities demonstrate that many non-white students experience stigma for "acting white" as associated with high-achievement (Delpit 2006; Fordham and Ogbu 1986; Mickelson 1990; Tyson, Darity Jr, and Castellino 2005), which is especially prevalent among STEM majors. This distancing to maintain gender and racial identities may help explain why women and minorities have weaker science identities.

Identity theory offers mechanisms to explain how students create distance between themselves and their possible future identities (like a science identity). Identity theory (IT) (Stets and Burke 2009) asserts that actors use an internal feedback loop to regulate their social behavior and the identities they internalize and maintain. In other words, this internal feedback process illuminates how actors internalize the stereotypical assumptions of what a given identity "should" look like—and thus, why it matters that scientists are typically seen as men and white. The process of having an important identity accepted or rejected by others is critical to understanding the creation and maintenance of identities.

According to IT, key to identity development and maintenance through interaction is how people learn how others view them. People compare a perceptual input (whether other group members seem to accept and support a presented identity) to their internal cognitive identity standard—how they believe they want to be viewed in their social roles. Based on this comparison, the individual's identity is *verified* if the feedback from social interaction matches the identity standard, or *not verified* if the perceived feedback from social interaction does not match the identity standard. Students who present and enact a "scientist" identity and find encouragement and support of this identity from others will have their science identities verified, while students who encounter ridicule or questioning will have their science identities not verified. When an individual's identities are verified, the individual is able to maintain his or her self-concept, and will continue to hold these identities. In contrast, lack of verification may lead to the rejection of an identity.

Performance of a science identity mixes students' perceptions of what it means to them to "do science" together with the cultural expectations of what it means to "do science." In other words, the historical legacy of men and whiteness carries expectations of what it means to be a scientist that are rooted in norms related to being a man, and to being white, that are frequently incongruous with women and people of color, thus offering a potential explanation for gender and racial disparities in STEM. When the cultural expectations based on historical legacies is a view of scientists as white men wearing lab coats and conducting science experiments (Thomson et al. 2019), this puts constraints on the characteristics and behaviors that will be accepted and allow for identities to be verified by others to strengthen students' science identity.

Factors Contributing to Science Identities

Through interactions people develop and refine the identities they want or need to maintain, while also receiving feedback about the appropriateness or acceptableness of the identities they claim. In this section I draw on Carlone and Johnson's (2007) research on what they call "dimensions" of identity at the cognitive level, and show how these dimensions undergird the processes of symbolic interactionism. Then, I bring social psychology to their formulation and build upon it by showing how identity theories suggest additional mechanisms through which their dimensions of competence, performance, and recognition may be central, as well as the importance of positive and negative emotions on the formulation of identity. The degree to which students are given the opportunity to perform their science identities, as well as to have them recognized by meaningful others is a function of their experiences in their courses and their affective responses.

Carlone and Johnson (2007) investigated the development of a science identity among women of color over the course of their undergraduate and graduate studies by combining aspects of previous ethnographic and interview data. As a result, they offer a model that conceptualizes identity as consisting of three dimensions: competence, performance, and recognition. Competence is one's possession of knowledge about, and facility with science content, skills, and practices. Performance is engagement in science practices in the public arena and culture of science, including demonstrating competence to other members of the science community. Recognition (or what symbolic interactionists call verification) refers to whether a person is recognized by herself or himself and/or by others as “a science person.” These dimensions may overlap. For example, someone may have high competence and performance within STEM, while having relatively low recognition. Students’ science identities are accessible when their scientific competence is displayed through their high quality performances, and recognized by meaningful others (Carlone and Johnson 2007). The importance of these factors in the development of a science identity has been supported by additional empirical research (Chang et al. 2014; Eagan Jr et al. 2013; Espinosa 2011; Hazari et al. 2013; Johnson 2007). Carlone and Johnson’s (2007) science identity model expanded on previous research to emphasize the effects of one’s gender, racial, and ethnic identities on their science identity.

Competence

By choosing a major, students are also making critical choices about the identities they want to take on as well. Previous research identifies competence as an important factor in students’ decisions to choose STEM fields (Bottia et al. 2015; King 2015; Moakler Jr and Kim 2014; Simon et al. 2017), and thus the initial step in formulating a science identity. Competence generally includes students’ abilities within the field, both to understand and conceptualize information scientifically, and can include measures such as GPA, rigor of courses, and previous coursework experience. Choosing a major is often a complex decision and if students do not feel competent within a field they are likely to choose another (Maltese and Tai 2011; Monforti and Michelson 2008), or leave the university entirely (Adamuti-Trache and Andres 2008). Therefore, many of the same processes that apply to choosing a major are important to students’ development of identities as well.

Undergirding this notion of competence, identity theory asserts that people prefer to have identities verified and supported by others, which is more likely when people can interact with others within their science identity role (related to performance and recognition). Research has found that students who felt more capable of succeeding and competent in a course tended to be more involved and engaged class participants (Zumbrunn et al. 2014), thus giving students more opportunities to interact and engage with others while enacting a science identity. Additionally, the more competence actors have, the better they will be able to match others' expectations of behavior for that identity. Thus, identities for which actors have competence are more likely to be verified.

Drawing on additional social psychological processes, stereotype threats and cultural beliefs may inhibit the relationship between students' competence and their science identity. Research on stereotype threat offers potential avenues though which competence can be an especially pressing issue for underrepresented groups within STEM. Stereotype threat processes (Steele and Aronson 1995) pertain to how activation of negative stereotypes of particular categories of students results in academic underperformance. Negative stereotypes that impugn women's math and science abilities create fear of confirming the stereotype, which then inhibits performance (Good et al. 2003). Studies reveal that such inhibited performance creates achievement gaps between men and women, and among white, black, and Hispanic students on math and science standardized tests (Spencer et al. 1999; Steele and Aronson 1995).

Experimental research on stereotype threat demonstrates that gender and racial stereotypes and bias deter students of color and women's STEM interest and achievement (Aronson et al. 1998; Shapiro and Williams 2012; Spencer et al. 1999). Exposure to peers' and professors' statements about students of color and women's inferiority in math and science negatively affects the behavior and attitudes of underrepresented groups towards math and science (Shapiro and Williams 2012; Spencer et al. 1999). Despite the equal skills of men and women and whites and non-whites in math and science fields, stereotypes that assume greater competence among men and whites persist and permeate cultural beliefs. These cultural beliefs are especially problematic when they lead to subtle or overt ways to treat students differently based on their race, gender, or social class, thus creating interactions that fail to verify students' science identities. Perception of competence is therefore an important factor for students in matching the cultural expectations for scientists, and will signal to students the extent to which their science identity is appropriate for them to claim, and will be verified by others, thus ensuring their "fit" within their chosen STEM field.

Hypothesis 1: Science competence is positively related to the strength of students' science identities.

Performance

Identity is more than what an individual says about one's relationship to, abilities in, interests, or aspirations regarding science, identity arises from the constraints and resources available in a setting (Carlone and Johnson 2007). Interactions with professors and peers within the college classroom communicate information about the feasibility of future identities—especially within disciplinary boundaries. Disciplinary and institutional cultures vary in terms of inclusivity, creating additional challenges for students who do not fit particular disciplinary expectations of a student. Disciplines convey the STEM culture in terms of stereotypical views and images of "scientists" (Cheryan, Drury, and Vichayapai 2013; Cheryan et al. 2015; Ozel 2012; Thomson et al. 2019), such as who and what types of people are the historical role models of "great" scientists. Additionally, what institutions do to help students feel comfortable, especially in the emphasized traits and characteristics of successful scientists (i.e., being systematic, getting published vs. diversity and equality), conveys elements of STEM culture. The extent to which students feel like they fit into a STEM field may vary based on what those students perceive to be the quintessential elements of “being a scientist,” and will involve a combination of students’ perceptions and the cultural expectations that emerge from the discipline.

Given the difficulty for students who fail to match-up to the stereotypical scientific images in verifying their science identity, Carlone and Johnson (2007) cast the science identity as fragile—defined as contingent and situationally emergent. Thus, they argue, to strengthen one’s science identity, it must be habitually accessed, performed, and recognized in various forms (presentations at conferences, participation in research labs, selection as a TA) to become stable and be carried across time and contexts (Carlone and Johnson 2007; Elmesky and Seiler 2007; Roth 2006).

To deepen this argument I draw again from Identity Theory, specifically theories that suggest that identify verification depends on performing or enacting identities identities for others, using language and behaviors that follow the norms associated with the identities being performed (Goffman 1959). In this framework, an audience for these performances can take the form of peers within the field (such as other scientists or students), mentors, or lay audiences outside of the field (Goffman 1959). That is, identities are not simply something that people have, but something actively performed and “done” for others (West and Zimmerman 1987). Previous STEM literature has drawn on this idea of performing identities to “doing” science (Archer et al. 2010; Williams and George-Jackson 2014) and learning the disciplinary and cultural rules for the appropriate ways to engage in scientific work. As students construct their science identities, they engage in performances of being a scientist that are important to the development of this identity (and especially learning behaviors that are consistent and inconsistent with these identities). For example, a student displaying his or her scientist identity at a conference must adhere to different norms compared to a display in the lab with other students, at a dinner party with other professionals, or among non-scientist friends and family. People's performances of their identities in front of others provides the opportunity for others to verify or fail to verify those identities. To strengthen their science identity and to have it verified by others, students must have an opportunity to perform it. To the extent that students engage successfully in various opportunities to perform their identities for others, they are more likely to strengthen their science identities.

> *Hypothesis 2:* Participation in more opportunities for identity performance (conferences, and paper publications, research opportunities) is positively related to the strength of students' science identities.

Recognition/Verification

Finally, I expand on Carlone and Johnson's (2007) concept of recognition by drawing again on verification. People have multiple identities, and each identity is tied to their relationships with other people (Stryker and Serpe 1994). The extent to which an individual engages with an identity across multiple situations and interactions with different people, the stronger this identity will be for that individual.[6] In addition, the more people who know and relate to an individual based on a particular identity, the stronger that identity will be, because there are more people who will "hold them" to that role (Stryker and Serpe 1994). To the extent that these relationships with others are important to the individual (i.e., significant others), the identity that ties them to those others are likely to be strengthened (Stryker and Serpe 1994).

More specifically, people tend to adhere to identities that bring the most confirmation and validation from others as their most important identities (Burke 1991; Callero 1985; McCall and Simmons 1978; Thoits 1983, 2003; Walker and Lynn 2013). If a student's important peers and authorities (e.g., professors) hold him or her to the science identity, the identity for that student grows stronger (Lee 2002; Stryker 1980). The fewer people that perceive that student to have a science identity and the less pressure the student feels to be cast as a scientist diminish the strength of the student's science identity.

Hypothesis 3: Recognition among significant others (parents, peers, teachers) is positively related to the strength of students' science identities.

Emotions

In this section I describe how students' emotional responses to their experience in STEM classes shapes their science identity. Identity theories help to explain why it is important to go beyond cognitive elements of an identity, and to also look at affective responses to experiences that bolster or diminish a science identity. Emotions are important motivators for actions and decisions, including those about one's future. Lawler and Thye (2006) define emotions as something internal to an actor stemming from conditions or events external to the actor that take various forms, and tend to range from positive to negative. People like to have confirmation and validation of their identities to think well of themselves (Weigert and Gecas 2005) and experience distress, depression, and lower self-esteem when identities are not verified (Stets and Burke 2009). Actors use their emotions to appraise the situation that evokes them (Thoits 1989). Students who experience positive emotions assess the situation that evoked those emotions in a more positive light, for example, receiving a good grade on a test and feeling encouraged for future tests.

Competence in an area and positive emotions can also be tied to identity processes. Students who perform more competently in an area related to their identities are more likely to receive verification, and thus, to experience positive emotions. For example, when students perform more competently in their STEM classes, they are more likely to have their science identities verified, and thus to feel positive emotions in relation to their work in the course. To the extent that people want to maximize positive emotions, and minimize negative emotions, students should be more likely to develop and maintain identities that are verified and evoke more positive emotions, than identities that are not verified and evoke negative emotions.

> *Hypothesis 4a:* Experiences of positive emotions associated with STEM courses is positively related to the strength of students' science identities.

Relatedly, experiences of negative emotions associated with behaviors related to an identity are likely to undermine that identity (Stets 2005).

> *Hypothesis 4b*: Experiences of negative emotions associated with STEM courses is negatively related to the strength of students' science identities.

Relationships of Science Identity on Persistence

Given that identities drive actions (Stets and Burke 2009), to the extent that students have strong science identities, they may be more likely to pursue courses related to the identity. Drawing from identity theory, Lee (1998) explains the links between gender, self-concepts, and perceptions of scientific others to investigate why individuals (especially women) interested in science fail to pursue these interests. Lee (1998) found that, compared to those who do not see themselves as scientists, "future scientists" are more likely to choose high school classes in science and math. In particular, discrepancies between the self-concepts of women and their perceptions of roles in science-related disciplines resulted in lower interest in those disciplines. As discussed earlier, it is likely that similar processes may operate for race, where if scientists are perceived as being white and economically advantaged, then students for whom their racial identity is important, may avoid "acting white" and consequently be unlikely to pursue science courses (Delpit 2006; Fordham and Ogbu 1986; Mickelson 1990; Tyson et al. 2005). Thus, as students' different types of identities affect their behavior, they will act in ways they believe will lead to verification, and thus maintain their self-meanings. Those identifying as a “science student” are likely to take more science classes to be consistent with that view.

The ways students come to see science as a set of experiences, skills, knowledge, and beliefs that are worthy (or unworthy) of their time and engagement may motivate changes in students’ sense of who they are and who they want to become (Cobb 2004).[7] People will act in accordance with what they believe will lead to verification to maintain identities (i.e., they will follow the expectations that are associated with their identities). Students who have developed and continue to maintain their science identities are more likely to apply and continue to enact these science identities in future STEM coursework despite possible identity alternatives (Stryker and Serpe 1994; Thoits 2013).

Hypothesis 6: The strength of students’ science identities is positively related to students’ intentions to continue taking future STEM courses.

Methods and Data Sources

In this study I focus on aspects of students’ experiences in the classroom that contribute to their science identities, and how students’ science identities signal their later persistence in STEM. I collected data from introductory courses in two disciplines that might range in how they shape students’ science identities: biology and computer science. Women and racial minorities remain underrepresented in the STEM workforce, with the greatest disparities occurring in engineering, computer science, and the physical sciences (National Science Board 2016). Comparatively, the biological sciences more successfully engage a diverse array of students (Sjøberg and Schreiner 2005). My analysis takes these contrasts into account by controlling for discipline.

I selected introductory courses as the focus of this study, because they act as gatekeepers (Seymour and N. M. Hewitt 1997; Tobias 1990). Gatekeeper courses refer to classes with high enrollment that generally represent the introductory courses required for matriculation into a major field of study (Tobias 1992), while also tending to have high enrollment, high levels of competition, large class sizes, and high failure rates (Tobias 1992; Valkenburg 1990). Particularly for science, math, and engineering majors, these courses represent the first course in a series required to graduate from the major. In addition, these courses are the first opportunity for students to learn more about the discipline, as well as the disciplinary norms and the ways each discipline approaches problems. Research finds that student performance in STEM gatekeeper courses helps to predict students who will graduate with a STEM degree, with a non-STEM degree, and those who will not graduate (Redmond-Sanogo et al. 2016), thus making introductory courses a useful place to observe students' initial foray into the STEM field in their undergraduate careers.

Sample

Study participants took either an introductory biology or computer science class during fall semester 2017 (n=388) and 2018 (n=398) at a R1 private university. As of fall 2017, the private university enrolled about 7,916 undergraduate students, with 41 percent white (non-Hispanic), 19 percent Asian, 17 percent non-resident international students, 8 percent black (non-Hispanic) students, and 9 percent Hispanic/Latino students (with 4 percent identifying as multiracial and 2 percent unknown). Table 3.1 shows the racial and gender representation of students in the biology and computer science department. In 2017, approximately 1,900 bachelor's degrees were awarded, with 191 students with a degree concentration in biology, and 55 in computer science. This university was selected for its diverse student population by race, and as a site where the introductory courses did not have any pre-requisites or specific intro courses segregating students by major or non-major. In addition, R1 schools in particular perform better than public institutions in students' persistence and degree completion rates in STEM fields, while also producing students who are actively recruited to work in STEM fields (Rine 2014).

[Table 3.1 about here]

Across the two semesters, 402 students enrolled in the biology course and 384 enrolled in the computer science course. These numbers represent students from four sections of Introduction to Biology, and six sections of Introduction to Computer Science. The same faculty member from biology (a black male) and from computer science (a white male) taught the sections each fall.[8] Students were recruited at the end of the fall semester to participate in the study. For the biology course there was a response rate of 104/206 (50.5 percent) for the fall 2017 semester and 82/196 (41.8 percent) for the fall 2018 semester. For the computer science course the response rate was 61/182 (33.5 percent) for the fall 2017 semester and 60/202 (29.7 percent) for the fall 2018 semester.[9]

Surveys

I emailed students an invitation and a link to the online survey to participate in a post-course survey on perceptions of their experiences within STEM courses after they had received their final grades for the course. As an incentive, students who completed a survey and provided their information via a separate form were given a $5 Amazon gift certificate. Students indicated their consent before taking the online survey.

Independent Variables

Competence. I measured competence by averaging two items to create a scale of self-reported assessments. Students' perceptions of their own competence were captured by responses on a seven-point scale (where 1 = strongly disagree and 7 = strongly agree). The survey asked students to indicate: "I expect to do well in science courses" as well as their ability to learn, "I will be good at learning something new in science." The bivariate correlation for these items is .78.

Performance involves participation in science practices in the public arena and culture of science, including demonstrating competence to other members of the science community. Performance was measured by a self-report of students' experiences performing as a science student. Students indicated the number of ways they pursued or performed science in the public arena: 1) awards, 2) selected to work in a lab/research assistant at your university, 3) selected to work in a lab/research assistant at another institution, 4) selected as a teaching assistant, 5) asked to tutor others, 6) secured grant funding, and 7) co-authored a publication or presentation. Students reported either that they had (1) these experiences, or did not (0), and their scores were summed to create a *performance scale*, ranging from 0 to 7.

Recognition refers to whether the person and/or others see the target as "a science person." Recognition by others was conceptualized with measures of "how much other people encouraged you to pursue a career in science, technology, engineering, or mathematics (STEM)?" on a seven-point scale (where 1 = not at all, 7 = very much) and was created as a scale consisting of: Family member(s), Friend(s) or other student(s), and Teacher(s). Based on principle component factor analyses, these items loaded on one factor allowing me to create a 3-item (α =.77) *recognition scale,* which averaged responses for family, friends, and teachers. Recognition of self was conceptualized with measures of "enjoy working in research labs," "enjoy scientific ways of thinking (e.g., logic, problem-solving, evidence-based reasoning)"; and "enjoy the subject matter of science" on a seven-point scale (where 1= strongly disagree, 7 = strongly agree). Principle component factor analysis indicated that these items loaded together to form the basis for the 3-item (α =.81) *self-recognition scale,* which averaged responses across the items.

Emotions. Students responded to the question: "how much did you typically feel each of the following [happy, excited, frustrated, encouraged, disappointed] about your biology or computer science class in general?" (where 1 = none at all and 7 = a great deal). Based on principle component factor analyses, I created two scales. The 3-item (α =.93) *positive emotion* scale averaged responses for happiness, excitement and encouraged and a 2-item (bivariate correlation = .87) *negative emotion* scale averaged responses for frustration and disappointment.

Controls. Students demographic characteristics include gender, race, and SES. I measure gender by a self-report of whether they identify as a man (0) or woman (1). To indicate race, I ask students' self-reported race as White/Caucasian, Black/African-American, Hispanic, Asian, or Native American. To test for an effect for students' race, I grouped respondents into three categories (white (0), black (1), and Asian (2)). I created a series of dummy variables to test for the effects of race, comparing white students to black students; white students compared to Asian students; and Asian students to black students. The results of these comparisons were largely not significant, so to simplify the models I used race as a white(0)/non-white(1) categorical variable. Data on income came from the respondents' reported parental income on a categorical scale (0=less than \$25,000, 1=\$25,001-\$50,000, 2=\$50,001 - \$75,000, 3=\$100,001 - \$150,000, 4=\$150,001 - \$200,000, 5=\$200,001 - \$250,000, 6=More than \$250,000). I also control for students' GPA, the time at which they were enrolled (fall 2017 [T=0] or fall 2018 [T=1]), and *Enrollment CS,* their course enrollment (where biology =0 and computer science =1).

Dependent Variables

Science/Math identity. I measured a student's science identity separately for their science and their math identity. Each identity measure consisted of 4 items. Students were asked to self-report (where 1 = strongly disagree, 7 = strongly agree) "How much do you disagree or agree with each of the following:" "I see myself as a science [math] person," "Others see me as a science [math] person," "For me, being good in science [math] is very important," and " Compared to most of my other activities, it is very important to be good at science [math]." Principle component factor analysis indicated that these items loaded together to form the basis of two 4-item scales for the *science identity* scale (α =.83) and the *math identity* scale (α =.85), which averaged responses for the four items for math or science, respectively.

Future intended STEM coursework (Persistence). To capture persistence, I asked students about their intent to pursue other coursework or a future in a biology or computer science. Students responded to the following (where 1 = not at all, 7= a great deal): "In general to what extent did you see your biology or computer science course as…: "a course you would take again," "the sort of work you expect after college," and "important to your future career" on a seven-point scale (where 1=not at all and 7=a great deal) Principle component factor analysis indicated that these items loaded together to form the basis of a 3-item scale (α =.82) which averaged responses across the items.

Analysis

To examine what contributes to a science identity and whether a science identity signals persistence in STEM I utilized a series of OLS regressions (Fox 2015). Due to missing data, I imputed data on ordinal and interval-ratio variables using multiple imputation (M=2). Below, I report the standardized coefficients for three models with math identity, science identity, and future intended STEM coursework as the dependent variables. In models 1 and 2 I examine factors hypothesized to strengthen math and science identities: competence, performance, and recognition as well as positive and negative emotions. Model 3 examines the effects of science identity and emotions on students' intent to pursue additional STEM coursework. All regressions include controls for gender, race, SES, GPA, course, and time of survey. Tests for multicollinearity for each model indicate low variance inflation factors (VIFs; 1.46 for all models, which is below the conventional 4.0 threshold) (O'Brien 2007). These results largely indicate multicollinearity was not present.

Results

Table 3.2 presents the means, standard deviations, and bivariate correlations among all measures. Results show that as expected, competence, recognition (both from others and self), performance, and positive emotions are positively correlated with science and math identities, as well as intentions to enroll in future STEM coursework.

[Table 3.2 about here]

Although the negative correlation between negative emotions and math identity (weaker negative emotions are associated with a stronger math identity) is in the expected direction, the positive correlation between negative emotions and future intended STEM coursework is unanticipated. As people generally try to avoid negative emotions, it is surprising that as students experience more negative emotions in their STEM classes, they also intend to pursue additional STEM coursework. Additionally, although not hypothesized my results show that competence and positive emotions are the most strongly associated with future intended STEM enrollment.

For the control variables, bivariate results show that gender (0=men, 1=women), and course enrollment (0=biology, 1=computer science) correlate negatively with science identity. These relationships suggest that female students and those enrolled in computer science express weaker science identities. In addition, gender correlates negatively with math identity indicating that a student's gender identity as a woman is associated with a weaker math identity. Finally, race and course enrollment correlate negatively with future intended STEM enrollment, suggesting that URMs and those enrolled in computer science have lower intentions to pursue additional STEM coursework. I first discuss the results with science identity, then math identity, followed by future intended STEM enrollment.

Science Identity

Model 1 in Table 3.3 examines the effects of competence, recognition, performance, and emotions on a student's science identity. Results confirm *Hypothesis 1*, predicting a positive relationship between competence and students' science identity ($\beta = .396$, $p < .000$). These results suggest that students' who perceive themselves to be more competent (distinct from a more objective GPA measurement of competence) report a stronger science identity. Results fail to confirm *Hypothesis 2,* predicting a positive relationship between performance and students' science identity. This indicates that the number of awards and presentations students have do not seem to strengthen their view of themselves as a science person.

[Table 3.3 about here]

Results confirm *Hypothesis 3,* predicting a positive relationship between students' self-recognition ($\beta = .452$, $p < .000$), and recognition by others ($\beta = .151$, $p < .001$) and their science identity, signaling that students who enjoy scientific ways of thinking and learning, as well as those who have others who help hold them to a science identity report a stronger science identity. Results fail to confirm *Hypothesis* 4, predicting a positive relationship between the reported experience of positive emotions and student's science identity. Similarly, no evidence emerges for *Hypothesis* 5, predicting a negative relationship between negative emotions and a student's science identity.

For the control variables, there were no significant effects of gender, race, class, or GPA. However, there was a significant negative effect for course enrollment ($\beta = -.109$, $p < .014$), signaling that students enrolled in computer science had a significantly weaker science identity compared to students enrolled in biology.

Math Identity

Model 2 in Table 3.3 examines the effects of competence, performance, recognition, and emotions on a student's math identity. Results confirm *Hypothesis 1*, which predicts a positive relationship between competence ($\beta = .226$, $p < .001$) and a student's math identity. These results suggest that students' who perceive themselves to be more competent (again, distinct from a more objective GPA measurement of competence) report a stronger math identity. Results fail to confirm *Hypothesis 2,* which predicts a positive relationship between performance and math identity.

Results provide partial support for *Hypothesis 3,* predicting a positive relationship between students' self-recognition ($\beta = .187$, $p < .006$), but without a significant relationship for recognition by others and math identity. This indicates that it matters more that students enjoy mathematical ways of thinking and math problems to increase their math identity, but that it does not matter as much that significant others support them in their math identities.

Results fail to confirm *Hypothesis 4,* predicting a positive relationship between positive emotions and students' math identity. Results confirm *Hypothesis 5,* predicting a negative relationship between negative emotions and math identity. These results suggest that students who experience fewer negative emotions in their courses report a stronger math identity.

Regarding the effects of the control variables, there were no significant effects of gender, race, class, or GPA. However, there were significant positive effects for students' enrollment in computer science ($\beta = .278$, $p < .000$) and their math identity. This suggests that students in computer science have a stronger math identity.

Intentions to enroll in future STEM courses

Model 3 in Table 3.4 examines the effects of competence, performance, recognition, emotions, and science and math identities on students' intent to persist in STEM courses. Results partially confirm *Hypothesis 6*, predicting a positive relationship between a student's science identity and their intent to persist within STEM. There was a significant relationship between students' science identity ($\beta = .373$, $p < .000$) and their intent to persist, but no significant relationship for students' math identity.[10] Unexpectedly, there was a significant positive relationship between negative emotions ($\beta = .216$, $p < .001$) and students' intended enrollment in future STEM courses. These results suggest that as students experience more negative emotions, they also report an intent to enroll in future STEM courses.

Regarding the effects of control variables, there were no significant effects for gender, SES, GPA, or enrollment. However, there was a negative, significant relationship between race ($\beta = -.126$, $p < .044$) and intent to enroll in a future STEM course, signaling that compared to whites, non-white students do not intend to pursue additional STEM coursework.

[Table 3.4 about here]

Discussion

This study investigates the cognitive and affective aspects of students' experiences in STEM that shape the strength of their science identities. In addition, I also examine the effects of students' science identities on their intent to enroll in future STEM classes. Carlone and Johnson (2007) suggest that competence, performance, and recognition serve as cognitive links that shape the strength of students' identities. I build on this work to explore the additional effects of positive and negative emotions on students' identities. Here I provide an initial analysis of how these cognitive and emotional aspects of students' experiences shape students' science identities and their intent to pursue future STEM courses. I make four observations about what matters in shaping students' science identities and persistence in STEM based on the results of my study. Overall, I argue for the expansion of the current focus on individual achievement and preparation processes to discuss how students' classroom experiences shape their ability to identify with and integrate within STEM, especially as that varies by gender and race.

First, consistent with Carlone and Johnson's (2007) model, some cognitive factors do matter in shaping students' science identities. As expected by *Hypothesis 1,* students who perceive themselves to be more competent report stronger science and math identities. As predicted in *Hypothesis* 3, recognition (from self and others) was also important for students' science identities, although only recognition from self (not others) was significant for students' math identity. Despite these results that support Carlone and Johnson's model, no evidence emerges for *Hypothesis 2;* students' performances did not have significant effects on their science or math identities. The students' performances measure assessed whether students had participated in a number of science-related activities such as presenting at conferences, publishing an article, or serving as a teaching assistant or research assistant. It may be that there was not enough variation in this measure (most students had not had any performance opportunities) to produce a significant result. Given that this is an introductory course, and most students have not had the opportunity to participate in science-related activities, this is not surprising. These patterns suggest that early in students' college careers their competence and self-recognition, along with recognition from others helps to strengthen their burgeoning science identities. Future research that surveys students further along in their college career, after students have had the opportunity to take part in opportunities to perform their science identities can better assess the relative impact of competence, recognition, and performance on students' more developed science identities, and how these factors may vary in importance at different points in time.

Second, emotions that students experience in response to their courses did not have a strong consequence on their identities, especially in comparison to cognitive factors. The findings provided no evidence for *Hypothesis* 5 (regarding positive emotions) and only limited evidence for *Hypothesis* 6 (regarding negative emotions) on students' science identity. As expected, there was a significant negative effect of negative emotions on students' math identities, signaling that students who experienced greater negative emotions regarding their science classes likewise reported weaker math identities. The absence of more consistent effects for emotional experiences on identities was surprising given extensive research on the role of emotions in identity processes (Stets 2005, 2006; Stets and Trettevik 2014). It is possible that the required nature of introductory coursework may make students feel that their emotions regarding the course hardly matter, as they must complete the course regardless of how they feel about it. Additionally, future research which explores a wider range of positive and negative emotions specifically asking for students' overall feelings about the course may be able to better distinguish the effects of students' emotions on their science identities.

Third, it appears that the type of identity matters for whether students persist in STEM. Results for Model 3 in Table 3.3 showed that students' science identities, but not their math identities were significant for their intent to enroll in future STEM courses. This signals that students' science identities are more important to their intentions to persist within STEM than students' math identities. This may indicate that some students do not consider math as centrally important to what they think of as STEM (perhaps relating to the image of a more stereotypical chemistry, biology, or engineering STEM). Unsurprisingly, students enrolled in computer science (where the use of math is much more prevalent), have a stronger math identity than students enrolled in biology (where math is less salient).

Finally, it may be that the negative emotional experiences shaping math identities contributes to this pattern of findings. Related research on employee turnover within organizations that suggests students' positive emotions are likely to increase their persistence intentions and persistence (Cohen 1993; Jaros et al. 1993; Tett and Meyer 1993), while negative emotions should predict students' leaving (Stets 2005). Yet, I also find that students who experience more negative emotions express an intent to enroll in future STEM courses. One possible explanation may be that students who did poorly in their STEM course may have experienced negative emotions, however, they may intend to re-take the course to improve their competence, as literature on "growth" mindsets of achievement suggest (Henry et al. 2019; Hernandez et al. 2013). It is also possible students experience negative emotions as a result of introductory coursework that is separate from their expectations of what future STEM coursework will hold. Future research that surveys students in more advanced (200 level or above) STEM coursework can help to assess the importance of emotions over the course of their college STEM classes.

In addition, white students are significantly more likely to express an intent to enroll in future STEM courses. While it is not surprising that white students who more easily "fit" into expectations for someone in STEM are more likely to enroll in future STEM courses, students' experiences of increased negative emotions and an intent to enroll in future STEM courses is unanticipated. However, this may be explained by emotions research which demonstrates that ideal emotions vary by culture, European American students generally want to feel positive, but not negative emotions, while some Asian cultures desire a balance of good and bad emotions (Koopmann-Holm and Tsai 2014; Tsai, Knutson, and Fung 2006). Future research that is better able to distinguish significant effects by race can explore potential influences of emotions that may vary by culture.

Future research can assess the generalizability of these results by measuring students in different educational contexts in addition to students' experiences at one private university in the Southeast. Future research would also benefit from sending the survey to students in additional STEM departments to examine the effects among a wider variety of STEM departments. This study also only measures a cross-sectional assessment of students' identities and intent to pursue additional STEM courses, and cannot make causal determinations of the importance of changes in identities over the course of the semester, or actual future enrollment in STEM courses. Ideally, a future study could aid in making causal determinations by measuring students' identities at two time points, at the beginning and end of the semester, and also tracking students' future enrollments to reveal more information about the long-term importance of students' identities and emotional evaluations of their courses as students have more experiences in their classes and academic departments (opportunities to take part in science-related activities, and more advanced coursework). Understanding the importance of students' identities and emotions over time can also highlight whether the key point of intervention for identity development is during introductory courses, earlier in secondary school, or later in college.

Students science identities are important to their intentions to persist in taking STEM courses. This is especially important for students who are finishing the introductory level STEM courses, a key juncture where they are also being introduced to courses and majors in other disciplines. Finding ways to help students to connect with science, and to see a potential future self as a scientist facilitates students' persistence within science. To help students to claim a science identity, they must perceive that they are competent. Failure to see oneself as competent creates an identity disruption that prompts students to change ideas about their identity (perhaps deciding that their science identity is not as central to their sense of self), to change their behaviors (perhaps encouraging them to study more), or to leave their science identities. In addition, important to helping students claim a science identity is supporting their ability to receive recognition from significant others, and to recognize their enjoyment of science as well. Students' ability to be recognized in their science identity provide critical opportunities for identity verification, and to find support for their enjoyment of science from relationships that are significant to the student. To the extent that there are different cultural beliefs surrounding the different courses, majors, and careers students intend to pursue, students may be motivated to strengthen or weaken their science identities to fit with their future goals. Future research that delves into identity processes on the importance of a science identity in relation to other identities may reveal more information about how to not only increase the strength of a science identity, as well as strengthening the connections between a science identity and their other identities.

Overall, my results suggest that students with a strong science identity intend to pursue additional STEM coursework. My results also indicate that improvements to students' perceptions of their competence, as well as the recognition of their abilities in STEM for themselves and by others help them to strengthen their science identity, and in turn encourage them to pursue additional STEM coursework. This study specifically highlights the social psychological and symbolic interactionist theoretical mechanisms that undergird these processes, and further link this identity work to the importance of a consideration of students' emotions in the process of identity development. My findings along with the underlying social psychological mechanisms suggest that identity verification from significant others like faculty, peers, and family members are especially important to strengthening students' science identities. To address the uneven progress in reducing STEM disparities, researchers can help students recognize the importance of their science identities for themselves, as well as investing in resources to create opportunities for students to get positive feedback on these identities from significant others.

Endnotes

[1] Stryker captures this idea as the notion of commitment, which represents the degree to which one's relationship with another person depends on that identity.

[2] Emotions may also shape persistence, but the focus here is on the development of students' science identities and the consequence of science identities.

[3]While I acknowledge that the instructor's race might influence students' reactions and experiences, it is not the focus of this study, and I focus here on students' science identities, leaving the influence of an instructor's race and gender to future research.

[4] The computer science class had a large enrollment of international students for whom English was not their first language, it is possible that the compensation offered to these students was not enough to complete a lengthy survey on their classroom experiences in English. In addition, the majority of these international students pay for their tuition without scholarships or aid, and thus, the $5 compensation offered may not have been enough to motivate them to respond to the survey.

[5] I ran additional models analyzing the influence of Competence, Performance, Recognition, and Emotions on persistence without the identity measures. In this model, recognition, negative emotions, and enrollment had significant effects on persistence. These additional analyses suggest that science identity mediates the significant effects of recognition and enrollment on students' intentions to enroll in future coursework, but not the effect of negative emotions.

Works Cited

Adamuti-Trache, Maria and Lesley Andres. 2008. "Embarking on and Persisting in Scientific Fields of Study: Cultural Capital, Gender, and Curriculum along the Science Pipeline." *International Journal of Science Education* 30(12):1557–84.

Archer, Louise, Jennifer DeWitt, Jonathan Osborne, Justin Dillon, Beatrice Willis, and Billy Wong. 2010. "'Doing' Science versus 'Being' a Scientist: Examining 10/11-year-old Schoolchildren's Constructions of Science through the Lens of Identity." *Science Education* 94(4):617–39.

Aronson, Joshua, Diane M. Quinn, and Steven J. Spencer. 1998. "Stereotype Threat and the Academic Underperformance of Minorities and Women." Pp. 83–103 in *Prejudice: The target's perspective*, edited by J. K. Swim and C. Stangor. New York: Academic Press.

Bottia, Martha Cecilia, Elizabeth Stearns, Roslyn Arlin Mickelson, Stephanie Moller, and Lauren Valentino. 2015. "Growing the Roots of STEM Majors: Female Math and Science High School Faculty and the Participation of Students in STEM." *Economics of Education Review* 45:14–27.

Burke, Peter J. 1991. "Identity Processes and Social Stress." *American Sociological Review* 56(6):836–49.

Callero, Peter L. 1985. "Role-Identity Salience." *Social Psychology Quarterly* 48(3):203–15.

Carlone, Heidi B. and Angela Johnson. 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.

Cech, Erin, Brian Rubineau, Susan Silbey, and Caroll Seron. 2011. "Professional Role Confidence and Gendered Persistence in Engineering." *American Sociological Review*

76(5):641–66.

Chang, Mitchell J., Jessica Sharkness, Sylvia Hurtado, and Christopher B. Newman. 2014. "What Matters in College for Retaining Aspiring Scientists and Engineers from Underrepresented Racial Groups." *Journal of Research in Science Teaching* 51(5):555–80.

Cheryan, Sapna, Benjamin J. Drury, and Marissa Vichayapai. 2013. "Enduring Influence of Stereotypical Computer Science Role Models on Women's Academic Aspirations." *Psychology of Women Quarterly* 37(1):72–79.

Cheryan, Sapna, Allison Master, and Andrew N. Meltzoff. 2015. "Cultural Stereotypes as Gatekeepers: Increasing Girls' Interest in Computer Science and Engineering by Diversifying Stereotypes." *Frontiers in Psychology* 6:49.

Cheryan, Sapna, Sianna A. Ziegler, Amanda K. Montoya, and Lily Jiang. 2017. "Why Are Some STEM Fields More Gender Balanced Than Others?" *Psychological Bulletin* 143(1):1–35.

Cobb, Paul. 2004. "Mathematics, Literacies, and Identity." *Reading Research Quarterly* 39(3):333–37.

Cohen, Aaron. 1993. "Organizational Commitment and Turnover: A Met A-Analysis." *Academy of Management Journal* 36(5):1140–57.

Cole, Darnell and Araceli Espinoza. 2008. "Examining the Academic Success of Latino Students in Science Technology Engineering and Mathematics (STEM) Majors." *Journal of College Student Development* 49(4):285–300.

Coleman, James S. 1968. *Equality of Educational Opportunity: By James S. Coleman and [Others]*. Vol. 1. US Department of Health, Education, and Welfare, Office of Education.

Correll, Shelley J. 2001. "Gender and the Career Choice Process: The Role of Biased Self-Assessments." *American Journal of Sociology* 106(6):1691–1730.

Delpit, Lisa. 2006. *Other People's Children: Cultural Conflict in the Classroom*. The New Press.

DiPrete, Thomas A. and Claudia Buchmann. 2013. *The Rise of Women: The Growing Gender Gap in Education and What It Means for American Schools*. Russell Sage Foundation.

Eagan Jr, M. Kevin, Sylvia Hurtado, Mitchell J. Chang, Gina A. Garcia, Felisha A. Herrera, and Juan C. Garibay. 2013. "Making a Difference in Science Education: The Impact of Undergraduate Research Programs." *American Educational Research Journal* 50(4):683–713.

Elmesky, Rowhea and Gale Seiler. 2007. "Movement Expressiveness, Solidarity and the (Re) Shaping of African American Students' Scientific Identities." *Cultural Studies of Science Education* 2(1):73–103.

Espinosa, Lorelle. 2011. "Pipelines and Pathways: Women of Color in Undergraduate STEM Majors and the College Experiences That Contribute to Persistence." *Harvard Educational Review* 81(2):209–41.

Ewert, Stephanie. 2010. "Male and Female Pathways through Four-Year Colleges: Disruption and Sex Stratification in Higher Education." *American Educational Research Journal* 47(4):744–73.

Fordham, Signithia and John U. Ogbu. 1986. "Black Students' School Success: Coping with the 'burden of "Acting White."'" *The Urban Review* 18(3):176–206.

Fox, John. 2015. *Applied Regression Analysis and Generalized Linear Models*. Ontario: Sage Publications.

Gecas, Viktor and Peter Burke. 1995. "Self and Identity." Pp. 41–67 in *Sociological Perspectives on Social Psychology. Boston, MA: Allyn and Bacon*, edited by K. S. Cook, G. A. Fine, and J. S. House. Boston, MA: Allyn and Bacon.

Gee, James Paul. 2000. “Identity as an Analytic Lens for Research in Education.” *Review of Research in Education* 25(1):99–125.

Goffman, Erving. 1959. *The Presentation of Self in Everyday Life*. Vol. 21. edited by U. O. Edinburgh. New York: Doubleday.

Good, Catherine, Joshua Aronson, and Michael Inzlicht. 2003. “Improving Adolescents' Standardized Test Performance: An Intervention to Reduce the Effects of Stereotype Threat.” *Journal of Applied Developmental Psychology* 24(6):645–62.

Hazari, Zahra, Philip M. Sadler, and Gerhard Sonnert. 2013. “The Science Identity of College Students: Exploring the Intersection of Gender, Race, and Ethnicity.” *Journal of College Science Teaching* 42(5):82–91.

Heaverlo, Carol Ann. 2011. “STEM Development: A Study of 6th-12th Grade Girls' Interest and Confidence in Mathematics and Science.” PhD dissertation, Department of Education, University of Iowa. Retrieved from: https://search.proquest.com/pqdtglobal/docview/894337556/abstract/109BA73E53504198PQ/112

Henry, Meredith A., Shayla Shorter, Louise Charkoudian, Jennifer M. Heemstra, and Lisa A. Corwin. 2019. “FAIL Is Not a Four-Letter Word: A Theoretical Framework for Exploring Undergraduate Students' Approaches to Academic Challenge and Responses to Failure in STEM Learning Environments.” *CBE—Life Sciences Education* 18(1).

Hernandez, Paul R., P. Schultz, Mica Estrada, Anna Woodcock, and Randie C. Chance. 2013. “Sustaining Optimal Motivation: A Longitudinal Analysis of Interventions to Broaden Participation of Underrepresented Students in STEM.” *Journal of Educational Psychology* 105(1):89.

Horvat, Erin McNamara and Kristine S. Lewis. 2003. "Reassessing the" Burden of'acting White'": The Importance of Peer Groups in Managing Academic Success." *Sociology of Education* 76:265–80.

Jaros, Stephen J., John M. Jermier, Jerry W. Koehler, and Terry Sincich. 1993. "Effects of Continuance, Affective, and Moral Commitment on the Withdrawal Process: An Evaluation of Eight Structural Equation Models." *Academy of Management Journal* 36(5):951–95.

Johnson, Angela C. 2007. "Unintended Consequences: How Science Professors Discourage Women of Color." *Science Education* 91(5):805–21.

King, Barbara. 2015. "Changing College Majors: Does It Happen More in STEM and Do Grades Matter?" *Journal of College Science Teaching* 44(3):44–51.

Koopmann-Holm, Birgit and Jeanne L. Tsai. 2014. "Focusing on the Negative: Cultural Differences in Expressions of Sympathy." *Journal of Personality and Social Psychology* 107(6):1092.

Lawler, Edward J. and Shane R. Thye. 2006. "Social Exchange Theory of Emotions." Pp. 295–320 in *Handbook of the Sociology of Emotions*, edited by J. H. Turner and J. E. Stets. New York: Springer.

Lee, James Daniel. 1998. "Which Kids Can 'Become' Scientists? Effects of Gender, Self-Concepts, and Perceptions of Scientists." *Social Psychology Quarterly* 61(3):199–219.

Lee, James Daniel. 2002. "More than Ability: Gender and Personal Relationships Influence Science and Technology Involvement." *Sociology of Education* 75(4):349–73.

Lee, Richard M. and Steven B. Robbins. 1995. "Measuring Belongingness: The Social Connectedness and the Social Assurance Scales." *Journal of Counseling Psychology* 42(2):232.

Maltese, Adam V and Robert H. Tai. 2011. "Pipeline Persistence: Examining the Association of Educational Experiences with Earned Degrees in STEM among US Students." *Science Education* 95(5):877–907.

Marlone, K. and G. Barabino. 2009. "Narrations of Race in STEM Research Settings: Identity Formation and Its Determinants." *Science Education* 93:486–510.

Mau, Wei-Cheng. 2003. "Factors That Influence Persistence in Science and Engineering Career Aspirations." *The Career Development Quarterly* 51(3):234–43.

McCall, George J. and Jerry L. Simmons. 1978. *Identities and Interactions: An Examination of Human Associations in Everyday Life (Rev. Ed.)*. New York: Free Press; Collier-Macmillan.

Mickelson, Roslyn Arlin. 1990. "The Attitude-Achievement Paradox among Black Adolescents." *Sociology of Education* 63:44–61.

Moakler Jr, Martin W. and Mikyong Minsun Kim. 2014. "College Major Choice in STEM: Revisiting Confidence and Demographic Factors." *The Career Development Quarterly* 62(2):128–42.

Monforti, Jessica Lavariega and Melissa R. Michelson. 2008. "Diagnosing the Leaky Pipeline: Continuing Barriers to the Retention of Latinas and Latinos in Political Science." *PS: Political Science & Politics* 41(01):161–66.

Morton, Terrell R. and Eileen C. Parsons. 2018. "# BlackGirlMagic: The Identity Conceptualization of Black Women in Undergraduate STEM Education." *Science Education* 102(6):1363–93.

National Science Board. 2016. *Science and Engineering Indicators 2016 NSF - National Science Foundation*.

O'brien, Robert M. 2007. "A Caution Regarding Rules of Thumb for Variance Inflation

Factors." *Quality & Quantity* 41(5):673–90.

Ozel, Murat. 2012. "Children's Images of Scientists: Does Grade Level Make a Difference?." *Educational Sciences: Theory and Practice* 12(4):3187–98.

Perez, Tony, Jennifer G. Cromley, and Avi Kaplan. 2014. "The Role of Identity Development, Values, and Costs in College STEM Retention." *Journal of Educational Psychology* 106(1):315–29.

Rainey, Katherine, Melissa Dancy, Roslyn Mickelson, Elizabeth Stearns, and Stephanie Moller. 2018. "Race and Gender Differences in How Sense of Belonging Influences Decisions to Major in STEM." *International Journal of STEM Education* 5(1):10.

Redmond-Sanogo, Adrienne, Julie Angle, and Evan Davis. 2016. "Kinks in the STEM Pipeline: Tracking STEM Graduation Rates Using Science and Mathematics Performance." *School Science and Mathematics* 116(7):378–88.

Riegle-Crumb, Catherine and Barbara King. 2010. "Questioning a White Male Advantage in STEM Examining Disparities in College Major by Gender and Race/Ethnicity." *Educational Researcher* 39(9):656–64.

Riegle-Crumb, Catherine, Barbara King, Eric Grodsky, and Chandra Muller. 2012. "The More Things Change, the More They Stay the Same? Prior Achievement Fails to Explain Gender Inequality in Entry into STEM College Majors over Time." *American Educational Research Journal* 49(6):1048–73.

Rine, P. Jesse. 2014. *Strengthening the STEM Pipeline: The Contributions of Small and Mid-Sized Independent Colleges.* Washington D.C.: Council of Independent Colleges.

Robnett, Rachael. 2013. "The Role of Peer Support for Girls and Women in the STEM Pipeline : Implications for Identity and Anticipated Retention." *International Journal of Gender,* *Science and Technology* 5(3):233–53.

Roth, Wolff-Michael. 2006. *Identity as Dialectic: Re/Making Self in Urban Schooling*. Westport, CT: Greenwood.

Seymour, Elaine and Nancy Hewitt. 1997. *Talking About Leaving: Why Undergraduates Leave the Sciences*. Boulder, CO: Westview Press.

Shapiro, Jenessa R. and Amy M. Williams. 2012. "The Role of Stereotype Threats in Undermining Girls' and Women's Performance and Interest in STEM Fields." *Sex Roles* 66(3–4):175–83.

Simon, Richard M., Ashley Wagner, and Brooke Killion. 2017. "Gender and Choosing a STEM Major in College: Femininity, Masculinity, Chilly Climate, and Occupational Values." *Journal of Research in Science Teaching* 54(3):299–323.

Sjøberg, Svein and Camilla Schreiner. 2005. "How Do Learners in Different Cultures Relate to Science and Technology? Results and Perspectives from the Project ROSE (The Relevance of Science Education)." *Asia-Pacific Forum on Science Learning and Teaching* 6(2):1–17.

Soh, Leen-Kiat, Ashok Samal, and Gwen Nugent. 2007. "An Integrated Framework for Improved Computer Science Education: Strategies, Implementations, and Results." *Computer Science Education* 17(1):59–83.

Spelke, Elizabeth S. 2005. "Sex Differences in Intrinsic Aptitude for Mathematics and Science?: A Critical Review." *American Psychologist* 60(9):950–58.

Spencer, Steven J., Claude M. Steele, and Diane M. Quinn. 1999. "Stereotype Threat and Women's Math Performance." *Journal of Experimental Social Psychology* 35(1):4–28.

Stage, Frances K. and Sue A. Maple. 1996. "Incompatible Goals: Narratives of Graduate Women in the Mathematics Pipeline." *American Educational Research Journal* 33(1):23–51.

Steele, Claude M. and Joshua Aronson. 1995. "Stereotype Threat and the Intellectual Test Performance of African Americans." *Journal of Personality and Social Psychology* 69(5):797–811.

Stets, Jan E. 2005. "Examining Emotions in Identity Theory." *Social Psychology Quarterly* 68(1):39–56.

Stets, Jan E. 2006. "Identity Theory and Emotions." Pp. 203–23 in *Handbook of the Sociology of Emotions*, edited by J. E. Stets and J. H. Turner. New York: Springer.

Stets, Jan E. and Peter James Burke. 2009. *Identity Theory*. New York: Oxford University Press.

Stets, Jan E. and Ryan Trettevik. 2014. "Emotions in Identity Theory." Pp. 33–49 in *Handbook of the sociology of emotions: Volume II*, edited by J. E. Stets and J. H. Turner. Springer, Dordrecht: Springer Netherlands.

Stryker, Sheldon. 1980. *Symbolic Interactionism*. Caldwell, NJ: The Blackburn Press.

Stryker, Sheldon and Richard T. Serpe. 1994. "Identity Salience and Psychological Centrality: Equivalent, Overlapping, or Complementary Concepts?" *Social Psychology Quarterly* 57:16–35.

Tai, Robert H., Christine Qi Liu, Adam V Maltese, and Xitao Fan. 2006. "Planning Early for Careers in Science." *Life Sci* 1:0–2.

Tellhed, Una, Martin Bäckström, and Fredrik Björklund. 2017. "Will I Fit in and Do Well? The Importance of Social Belongingness and Self-Efficacy for Explaining Gender Differences in Interest in STEM and HEED Majors." *Sex Roles* 77(1–2):86–96.

Tett, Robert P. and John P. Meyer. 1993. "Job Satisfaction, Organizational Commitment, Turnover Intention, and Turnover: Path Analyses Based on Meta-analytic Findings." *Personnel Psychology* 46(2):259–93.

Thoits, Peggy A. 1983. “Multiple Identities and Psychological Well-Being: A Reformulation and Test of the Social Isolation Hypothesis.” *American Sociological Review* 49:174–87.

Thoits, Peggy A. 1989. “The Sociology of Emotions.” *Annual Review of Sociology* 15(1):317–42.

Thoits, Peggy A. 2003. “Personal Agency in the Accumulation of Multiple Role-Identities.” Pp. 179–94 in *Advances in identity theory and research*, edited by P. J. Burke, T. J. Owens, R. T. Serpe, and P. A. Thoits. Boston, MA: Springer.

Thoits, Peggy A. 2013. “Volunteer Identity Salience, Role Enactment, and Well-Being: Comparisons of Three Salience Constructs.” *Social Psychology Quarterly* 76(4):373–98.

Thomson, Margareta M., Zarifa Zakaria, and Ramona Radut-Taciu. 2019. “Perceptions of Scientists and Stereotypes through the Eyes of Young School Children.” *Education Research International* 2019:1–13.

Tobias, Sheila. 1990. “Stemming the Science Shortfall at College.” in *They’re not dumb, they’re different*, edited by S. Tobias. Tucson, AZ: Research Corporation.

Tobias, Sheila. 1992. “Science Education Reform What’s Wrong with the Process?” *Change: The Magazine of Higher Learning* 24(3):12–19.

Tsai, Jeanne L., Brian Knutson, and Helene H. Fung. 2006. “Cultural Variation in Affect Valuation.” *Journal of Personality and Social Psychology* 90(2):288.

Tyson, Karolyn, William Darity Jr, and Domini R. Castellino. 2005. “It’s Not ‘a Black Thing’: Understanding the Burden of Acting White and Other Dilemmas of High Achievement.” *American Sociological Review* 70(4):582–605.

Ulriksen, Lars, Lene Møller Madsen, and Henriette T. Holmegaard. 2010. “What Do We Know about Explanations for Drop out/Opt out among Young People from STM Higher Education

Programmes?" *Studies in Science Education* 46(2):209–44.

Valkenburg, M. E. Van. 1990. "An Engineering Curriculum for the Future." *IEEE Communications Magazine* 28(12):12–15.

Walker, Mark H. and Freda B. Lynn. 2013. "The Embedded Self: A Social Networks Approach to Identity Theory." *Social Psychology Quarterly* 76(2):151–79.

Wang, Xueli. 2013. "Why Students Choose STEM Majors: Motivation, High School Learning, and Postsecondary Context of Support." *American Educational Research Journal* 50(5):1081–1121.

Weigert, Andrew J. and Viktor Gecas. 2005. "Symbolic Interactionist Reflections on Erikson, Identity, and Postmodernism." *Identity* 5(2):161–74.

West, Candace and Don H. Zimmerman. 1987. "Doing Gender." *Gender & Society* 1(2):125–51.

Williams, Montrischa M. and Casey George-Jackson. 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):99–126.

Xie, Yu, Michael Fang, and Kimberlee Shauman. 2015. "Stem Education." *Annual Review of Sociology* 41:331–57.

Xie, Yu and Alexandra A. Killewald. 2012. *Is American Science in Decline?* Harvard University Press.

Xie, Yue and Kimberlee A. Shauman. 2003. *Women in Science: Career Processes and Outcomes*. Vol. 26. Harvard University Press Cambridge, MA.

Zumbrunn, Sharon, Courtney McKim, Eric Buhs, and Leslie R. Hawley. 2014. "Support, Belonging, Motivation, and Engagement in the College Classroom: A Mixed Method Study." *Instructional Science* 42(5):661–84.

Figure 3.1. Theoretical Model

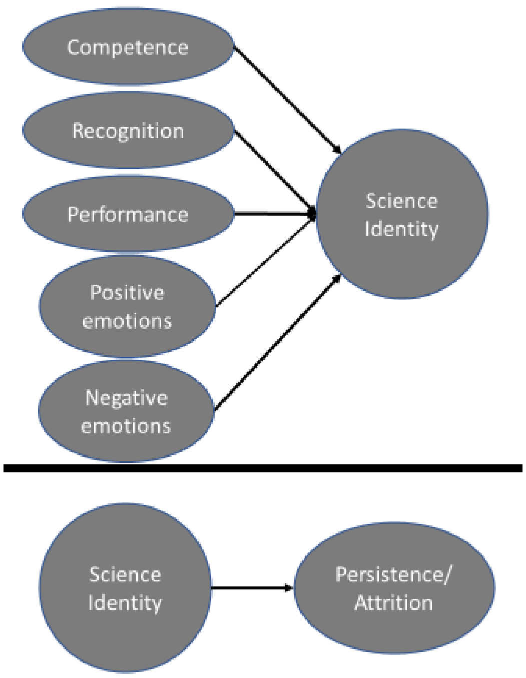


Table 3.1. Percentages of Students Enrolled in Computer Science or Biology Courses at the Private University in 2018-19

All enrolled Students			Students by Major In total numbers	
Ethnicity	**CS %**	**Bio %**	**CS**	**Bio**
Total	100%	**100%**	**38**	**338**
Am. Indian	0.0%	0.1%	0	0
Asian	25.9%	33.6%	10	116
Black	3.5%	8.0%	1	25
Hispanic	5.8%	10.6%	1	36
Multi	3.2%	4.1%	1	21
Non US Citizen	39.5%	10.9%	15	39
Unknown	0.0%	1.3%	1	6
White	22.1%	31.4%	9	95
Gender				
Female	38.9%	60.6%	8	212
Male	61.1%	39.4%	30	126

Table 3.2. Bivariate Correlation Matrix with Means (and Standard Deviations) on the Diagonal (n= 248)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1) Science ID	5.23(1.14)														
(2) Math ID	0.347*	4.88(1.33)													
	0.000														
(3) Future STEM	0.388*	0.123*	4.46(1.61)												
	0.000	0.044													
(4) Competence	0.583*	0.350*	0.200*	5.50(1.20)											
	0.000	0.000	0.001												
(5) Recognition Others	0.397*	0.172*	0.238*	0.251*	4.75(1.38)										
	0.000	0.005	0.000	0.000											
(6) Recognition Self	0.665*	0.272*	0.310*	0.384*	0.232*	5.14(1.28)									
	0.000	0.000	0.000	0.000	0.000										
(7) Performance	0.329*	0.176*	0.247*	0.236*	0.262*	0.375*	1.02(1.3)								
	0.000	0.004	0.000	0.000	0.000	0.000									
(8) Pos Emotions	0.253*	0.191*	0.167*	0.214*	0.201*	0.194*	0.084	4.31(1.74)							
	0.000	0.002	0.004	0.000	0.001	0.001	0.146								
(9) Neg Emotions	0.102	-0.137*	0.165*	0.111	-0.005	0.041	-0.092	0.297*	4.16(1.75)						
	0.084	0.024	0.005	0.058	0.938	0.486	0.109	0.000							
(10) Women	-0.125*	-0.219*	0.032	-0.221*	0.097	-0.085	-0.016	-0.160*	0.003	.65(.49)					
	0.015	0.000	0.585	0.000	0.059	0.099	0.748	0.006	0.954						
(11) Non-White	-0.049	0.011	-0.131*	-0.144*	-0.096	-0.123*	-0.009	0.121*	0.021	0.029	.58(.49)				
	0.425	0.853	0.031	0.018	0.115	0.044	0.879	0.046	0.735	0.634					
(12) SES	-0.022	0.026	-0.059	0.066	0.110*	0.041	0.092	-0.010	-0.030	0.035	-0.239*	3.62(2.12)			
	0.668	0.677	0.322	0.203	0.034	0.433	0.074	0.861	0.610	0.497	0.000				
(13) GPA	0.029	-0.003	0.081	0.255*	-0.067	0.074	0.138*	0.113	0.153*	0.107*	-0.031	0.237*	3.50(.43)		
	0.580	0.956	0.183	0.000	0.201	0.156	0.008	0.058	0.010	0.040	0.616	0.000			
(14) Enrollment CS	-0.126*	0.278*	-0.233*	-0.009	-0.099	-0.148*	-0.086	-0.048	-0.193*	-0.142*	-0.057	-0.049	0.003	.37(.48)	
	0.016	0.000	0.000	0.859	0.058	0.004	0.080	0.407	0.001	0.006	0.354	0.356	0.950		
(15) Time	-0.016	-0.045	-0.015	0.002	-0.127*	0.010	0.061	-0.033	-0.012	-0.078	0.056	-0.014	0.025	0.064	.40(.49)
	0.758	0.461	0.794	0.965	0.013	0.851	0.202	0.572	0.838	0.126	0.357	0.785	0.632	0.196	

* shows significance at the .05 level

Table 3.3. Ordinary Least Squares Standardized Regression Coefficients (standard errors) for Effects of Competence, Recognition, Performance, and Emotions on Science Identity and Math Identity

	Model 1			**Model 2**		
	Science ID			***Math ID***		
IVs	Beta		Std. Err.	Beta		Std. Err.
Competence	0.396	***	0.04	0.226	***	0.08
Recognition - Others	0.151	***	0.03	0.065		0.06
Recognition - Self	0.452	***	0.04	0.187	**	0.08
Performance	0.001		0.04	0.018		0.06
Pos Emotions	0.051		0.03	0.115		0.05
Neg Emotions	-0.002		0.03	-0.132	*	0.05
Women	0.001		0.10	-0.071		0.18
Nonwhite	0.056		0.09	0.072		0.16
SES	0.000		0.02	0.047		0.04
GPA	-0.033		0.12	-0.035		0.21
Enrollment CS	-0.109	**	0.10	0.278	***	0.18
Time	0.036		0.09	-0.016		0.15
_cons	.		0.48	.		0.85
R^2 (adjusted)	0.609			0.231		

Notes: N=248. *p<.05 **p<.01 ***p<.001 (two-tailed test)

Table 3.4. Ordinary Least Squares Standardized Regression Coefficients (standard errors) for Effects of Competence, Recognition, Performance, Emotions, Science Identity, and Math Identity on Future Intended STEM Coursework

	Model 3 ***Future STEM***		
IVs	Beta		Std. Err.
Science ID	0.373	***	0.11
Math ID	0.062		0.06
Competence	-0.026		0.09
Recognition - Others	0.019		0.06
Recognition - Self	0.009		0.08
Performance	-0.056		0.06
Pos Emotions	-0.073		0.05
Neg Emotions	0.216	***	0.05
Women	0.040		0.17
URMs	-0.126	*	0.15
SES	-0.074		0.04
GPA	0.074		0.20
Enrollment CS	-0.049		0.18
Time	0.004		0.15
_cons	.		0.81
R^2 (adjusted)	0.1819		

Notes: N=248. *p<.05 **p<.01 ***p<.001 (two-tailed test)

Chapter 4: Conclusion

Despite the plethora of studies on STEM persistence and the disparities within STEM since the 1990s, uneven progress has been made in substantially increasing women and underrepresented groups across STEM disciplines. The time students spend in their post-secondary education critically influences their future development as people, employees, citizens of a nation, consumers, activists, and many other identities and roles. The three chapters of my dissertation utilized overlooked social psychological processes (see Xie, Fang, and Shauman 2015) to address the lack of diversity in STEM fields by augmenting existing work regarding why women and students who are underrepresented minorities (URMs) persist in STEM fields at lower levels compared to men and whites.

My dissertation research utilized observational data of all offered biology and computer science courses in the Fall of 2017, as well as cross sectional survey data from two cohorts of students in the Fall of 2017 and 2018. I investigated the classroom climate, students' experience of classroom dynamics through justice and status processes, and the development of students' science identity. My focus at the higher education level, and integration of sociology of education and social psychology allowed me to identify ways interactions within institutions can ameliorate educational inequalities in STEM. Social psychological processes have successfully been used for decades to reveal the consequences of the nature of interactions within organizations, and in this dissertation, I provide starting points to transition these understandings to higher education STEM classrooms. In the following sections, I discuss the main contributions of each paper and then propose directions for future research.

Looking Beyond Mitigating or Thawing the Chilly Climate: Creating a Hospitable Climate

What is the importance of the way researchers discuss and structure research on classroom climates? Previous literature focuses on the influences of the chilly climate, and limiting characteristics of a chilly climate. By focusing on the negatives, and simply the avoidance of the chilly climate, research fails to address the more proactive, positive elements of the classroom that can be introduced to help draw students in and engage them. In Chapter 1, I argued for an expansion of the classroom climate focused on the singular dimension of the chilly climate, to discuss another dimension: the hospitable climate. I argue for a broader reconceptualization of STEM classrooms to distinguish and amplify factors that welcome students and lead to features that draw students in.

The stark contrast of a chilly climate vs. a not-chilly climate fails to captures the complexity of experiences that students have in their STEM classes that may drive them out of STEM, or encourage them to persist. My findings contradict the implications of previous research that biology would have a more positive climate compared to computer science. My data indicate a more complicated picture, with characteristics of hospitableness and chilliness in both fields. Hospitable classrooms are more than just those that lack a chilly climate, instead hospitable climates involve active amplification of classroom practices that specifically welcome women and URMs. I build on the chilly climate literature to contribute to the less researched influences of the micro-interactional level (the classroom-level) on experiences that shape students’ decisions about their futures.

Effects of Fairness and Social Characteristics on Undergraduate STEM Students’ Emotions and Perceptions of Competence

How do students’ assessments of classroom dynamics shape their reactions to their STEM experiences? Prior research in education seeking to explain the factors related to entrance into and exiting from STEM fields look to students' individual interests, previous experience, competence, attitudes, and values (Eccles 1989; Holland 1997; Lent et al. 2005; Watt and Eccles 2008). I move beyond these background factors to consider whether students themselves perceive the dynamics in STEM classrooms, and associate these classroom dynamics with their broader thoughts about the field. While the effects of students' previous experiences on their continuance in STEM has been well-documented, little research investigates conditions that may shape students' perceptions of their competence. I examine students' assessments of justice and status processes in the form of classroom dynamics as they shape students' immediate and long-term reactions to their STEM experiences.

Findings indicate that STEM students' concerns about their outcomes (i.e., fairness of grades) and treatment from their professors shape their emotional responses, whereas considerations of interpersonal justice (by both professors and peers) shape their assessments of competence. My results suggest that to ensure students experience more positive than negative emotions during their experiences in STEM courses, faculty and departments train instructors to ensure interpersonal justice, and help students to adjust the way they think about the importance of their grades. Results also suggest that gender shapes both individuals' emotions and assessments of competence, while race only shapes competence and SES only shapes students' emotions. In Chapter 2, I demonstrate ways that justice and status processes in the classroom influence students' emotional and cognitive responses, both of which may matter for students' persistence in STEM fields that may ultimately reduce disparities in those disciplines. Despite the stressfulness of gatekeeper courses in many STEM disciplines, and the high uncertainty students face surrounding the long-term career implications of declaring an academic major, the importance of emotional responses to STEM courses are often overlooked.

Factors in the College Classroom that impact Students' Science Identities and Persistence

What matters for students' development and solidification of a science identity, and how does their science identity shape persistence in STEM? Reducing the disparities in STEM fields requires both increasing the number of diverse students enrolling in STEM courses, as well as retaining the students who enroll. Previous research that seeks to explain the persistence of students already within STEM addresses the importance of students' interests, aspirations, as well as family and contextual factors (Cech et al. 2011; Riegle-Crumb et al. 2012; Soh et al. 2007; Ulriksen et al. 2010). Previous research also rests on the assumption that helping students overcome deficits in prior knowledge, will make students more confident in their abilities, and thus persist in STEM (Ulriksen et al. 2010). Studies focused on students' science identities seek both to explain how students become interested in STEM to enroll in a class, as well as how their identities keep them in STEM fields. In particular, theories of identity (Stets 2005; Stets and Burke 2009; Stryker 1980) serve as a useful lens to draw attention to the intersections of identities and the particular nature of STEM fields that makes it challenging for students to be included with a background other than white and male (Marlone and Barabino 2009).

My work in Chapter 3 builds upon the small-sample qualitative studies regarding cognitive aspects of students experiences (Carlone and Johnson 2007), to include the role of positive and negative emotions on students' science identities. My results indicate that improvements to students' perceptions of their competence, as well as the recognition of their abilities in STEM for themselves and by others help them to strengthen their science identity, and in turn encourage them to pursue additional STEM coursework. This study specifically highlights the social psychological and symbolic interactionist theoretical mechanisms that undergird these processes, and further link this identity work to the importance of a consideration of students' emotions in the process of identity development. My results suggest that students' science identities are important to their intentions to take additional STEM courses in the future. Thus, I suggest that interventions that help students to strengthen their science identity may help to reduce attrition in STEM.

Future Research Directions

Looking forward, I see three general directions for future research. First, future work should utilize longitudinal data to allow stronger claims about the importance of justice and status processes, emotions, competence, and students' science identities on their actual decisions to persist within a STEM field. My findings indicate the importance of students' science identities in their intentions to persist in future STEM courses, and helping students to connect with science. In addition, important to helping students claim a science identity is supporting their ability to receive recognition from significant others, and to recognize their enjoyment of science as well. To build on this work following students over time, and gathering additional, linked, longitudinal data would provide a stronger basis to make claims about the importance of students' responses to justice and status processes in terms of their emotions and competence, as well as their identities over the course of their undergraduate careers.

My study offers possible areas of intervention to help improve students' positive emotional reactions to their STEM courses, as well as areas that help them perceive themselves as being more competent in science. Future work utilizing longitudinal data can assess the changing influence of justice and status processes in the classroom over the course of students' undergraduate experience. It is possible that the effect of injustices in the classroom may compound over time as they occur in classes after the introduction course, and thus may result in stronger negative emotions and lower perceptions of competence as students experience more STEM courses. In addition, future research that distinguishes between expressions and experiences of emotions in response to classroom dynamics may shed more light on the emotional responses of women, URMs and lower SES students in STEM courses. Longitudinal research would enable researchers determine times during students' undergraduate careers where they may be particularly sensitive to justice and status processes in the classroom.

Longitudinal data can help to build on my findings to understand more clearly the *process* of how students' experiences and their perceptions of these experiences can promote persistence in STEM education, and how these processes may vary not only over time, but by race, gender and class. While white students were significantly more likely to express an intent to enroll in future STEM courses, future research that is able to address a wider range of negative emotions may be able to distinguish the unanticipated effects of negative emotions on students' intent to enroll in future STEM courses (especially as this effect may operate differently for women and URMs). Additional data on students' experiences over time would provide more concrete strategies to work to retain students in STEM that may vary across the course of their time in college.

Second, other social psychological research is needed to expand on my findings within a small-private university to encompass more institutions including community colleges, and public state institutions as well. My findings elaborate on the importance of class size and the physical classroom design that are more readily addressed at private universities, but may pose greater challenges for larger public universities. It stands to reason that the successful experiences at a private university are not necessarily the same at community colleges and public institutions. To resolve the issues of disparities in STEM, research should expand a utilization of social psychological elements to investigate differences in student outcomes not only at elite private universities, but also at two- and four-year public institutions, which arguably encounter far greater numbers of students (and often more of these underrepresented students as well).

Furthermore, my findings highlighting concrete classroom practices in Chapter 1 suggest that it is important not only to include quantitative survey results of students' experiences as I did in Chapters 2 and 3, but to also provide qualitative observations of students' classroom experiences. Future researchers can conduct interviews with students who are surveyed and observed to assess from the students' perception the extent to which they are consciously aware of the influences of classroom practices on their cognitive and affective experiences, as well as their future decision making. In addition, researchers might also be able to assess students' reactions through access to students' qualitative comments on teaching evaluations at the end of the semester. Gathering quantitative and qualitative data may also be beneficial to identify additional specific classroom practices that shape students' educational journeys as well as how students then perceive these educational environments.

Third, my dissertation focuses on the experiences of students within STEM, and future work can build on this with additional work drawing from the extensive drop-out rate literature in higher education. Future work that explores characteristics unique to specific academic disciplines to uncover interdisciplinary strategies for retaining students in higher education beyond small class sizes and or a changed curriculum. My dissertation highlights ways that any academic discipline may contain chilly or hospitable elements that push students to other disciplines or help to pull them in. My findings suggest that even within STEM fields, biology and computer science courses contain characteristics that make up both dimensions of a hospitable and chilly climate, and I suggest that the same may be true in the humanities and social sciences.

Attrition within STEM is a large challenge, with 48 percent of bachelor's degree students and 69 percent of associate's degree students who entered STEM fields between 2003 and 2009 leaving without a STEM degree by spring 2009 (Chen and Soldner 2013). It is possible some of the more successful academic fields may have strategies beyond those the literature has previously identified such as reducing class size (Bettinger and Long 2018; Cuseo 2007; Toth and Montagna 2002) and changing curriculums to reduce attrition. Identifying how students may respond similarly or differently to justice and status processes, and the influence of a students' "humanity identity" or "social science identity" may help to reveal strategies for improving persistence within STEM. Additionally, the steps that other disciplines take to specifically recruit and retain women and URMs are critical for evaluating what is missing to engage these students in STEM fields. College is a critical time in the identity development for students, and their time over the course of beginning college to finishing college brings different challenges and experiences that require a wider variation of interventions over time. My findings in Chapter 3 suggest the utility of strategies that emphasize scientific learning communities (Baker and Pomerantz 2000; Dagley et al. 2016) or other structures that can utilize an emphasis on students' STEM identity while providing opportunities for performance and verification of the science identity as particularly useful to STEM disciplines in reducing attrition.

Overall, my dissertation contributes to broader discussions on disparities within STEM by examining the social psychological processes in classrooms that may lead to some students to choose to stay in STEM, which may be helpful for women and URM students. Students were more engaged in courses where professors took the time to engage in open discussion about the diversity and mentoring of women and URM students. Open discussion about student diversity helped highlight that the department valued them and had resources dedicated to supporting them during their undergraduate careers, and appeared to contribute to the increased participation of women and URMs in these courses as I observed in Chapter 1.

Additional future research should move beyond simply trying to retain students to developing a richer understanding of how to improve students' undergraduate college experience and how they learn while in college overall. My results in Chapter 1 suggest the value of not only avoiding chilly classroom practices, but amplifying hospitable classroom practices. Future research building on my findings in Chapter 1 on the importance of helping students to think beyond the memorization of decontextualized facts and concepts in STEM (Archer et al. 2010; Badri et al. 2016; Osborne et al. 2003) and other fields can provide more concrete instructions for structuring classes that allow students to apply their knowledge outside of the classroom more frequently.

A central theme characterizing my dissertation is the usefulness of social psychological principles in the investigation of educational inequalities. The vast research within social psychology in understanding how to improve the attitudes, motivations, and behaviors of individuals in organizations can be readily translated to the college and university spheres with caveats for the possible differences in the nature of the faculty-student relationships that may differ from employer-employee relationships. My research here has worked to translate the micro-interactions that occur in the classroom to enact practices that are actively welcoming and hospitable for women and URMs in STEM. Programs that help students to detach their perceived competence from their or others' personal status attributes through providing examples of important women and URM figures in STEM may help women and URMs to see themselves as more competent, and to solidify their science identities. In addition, schools that can offer concrete ways to help students make more positive associations with their STEM experiences may offer a useful pathway to encourage persistence in STEM. Further, my work has captured the utility of justice and status processes on understanding the role of students' cognitive and affective responses to their classes, and how these cognitive and affective responses may have further implications on students' development of a science identity to improve their persistence. This research can help to understand how to utilize students' identities within their chosen career path to help improve their ability to learn and succeed in these fields before they graduate college and enter the job market. With this research as a starting point, I have highlighted the importance of students' experiences within the classroom, and how their perceptions of these experiences influence their cognitive and affective responses that shape how they relate to STEM fields. Future researchers should continue to utilize social psychological frameworks and theoretical lenses to develop a richer understanding of the importance of social interactions throughout students' undergraduate careers that can be utilized to improve students' educational experiences.

Works Cited

Archer, Louise, Jennifer DeWitt, Jonathan Osborne, Justin Dillon, Beatrice Willis, and Billy Wong. 2010. "'Doing' Science versus 'Being' a Scientist: Examining 10/11-year-old Schoolchildren's Constructions of Science through the Lens of Identity." *Science Education* 94(4):617–39.

Badri, Masood, Ali Alnuaimi, Jihad Mohaidat, Asma Al Rashedi, Guang Yang, and Karima Al Mazroui. 2016. "My Science Class and Expected Career Choices—a Structural Equation Model of Determinants Involving Abu Dhabi High School Students." *International Journal of STEM Education* 3(1):12.

Baker, Stephanie and Norleen Pomerantz. 2000. "Impact of Learning Communities on Retention at a Metropolitan University." *Journal of College Student Retention: Research, Theory & Practice* 2(2):115–26.

Bettinger, Eric P. and Bridget Terry Long. 2018. "Mass Instruction or Higher Learning? The Impact of College Class Size on Student Retention and Graduation." *Education Finance and Policy* 13(1):97–118.

Carlone, Heidi B. and Angela Johnson. 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.

Cech, Erin, Brian Rubineau, Susan Silbey, and Caroll Seron. 2011. "Professional Role Confidence and Gendered Persistence in Engineering." *American Sociological Review* 76(5):641–66.

Chen, Xianglei and Matthew Soldner. 2013. "STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report." *Report NCES 2014–001, US Dept. of Education*.

Cuseo, Joe. 2007. “The Empirical Case against Large Class Size: Adverse Effects on the Teaching, Learning, and Retention of First-Year Students.” *The Journal of Faculty Development* 21(1):5–21.

Dagley, Melissa, Michael Georgiopoulos, Amber Reece, and Cynthia Young. 2016. “Increasing Retention and Graduation Rates through a STEM Learning Community.” *Journal of College Student Retention: Research, Theory & Practice* 18(2):167–82.

Eccles, Jacquelynne S. 1989. “Bringing Young Women to Math and Science.” Pp. 36–58 in *Gender and thought: Psychological perspectives*, edited by M. Crawford and M. Gentry. New York: Springer-Verlag.

Holland, J. L. 1997. *Making Vocational Choices: A Theory of Vocational Personalities and Work Environments*. 2nd ed. Odessa, FL: Psychological Assessment Resources.

Lent, Robert W., Steven D. Brown, Hung-Bin Sheu, Janet Schmidt, Bradley R. Brenner, Clay S. Gloster, Gregory Wilkins, Linda C. Schmidt, Heather Lyons, and Dana Treistman. 2005. “Social Cognitive Predictors of Academic Interests and Goals in Engineering: Utility for Women and Students at Historically Black Universities.” *Journal of Counseling Psychology* 52(1):84.

Marlone, K. and G. Barabino. 2009. “Narrations of Race in STEM Research Settings: Identity Formation and Its Determinants.” *Science Education* 93:486–510.

Osborne, Jonathan, Shirley Simon, and Sue Collins. 2003. “Attitudes towards Science: A Review of the Literature and Its Implications.” *International Journal of Science Education* 25(9):1049–79.

Riegle-Crumb, Catherine, Barbara King, Eric Grodsky, and Chandra Muller. 2012. “The More Things Change, the More They Stay the Same? Prior Achievement Fails to Explain Gender

Inequality in Entry into STEM College Majors over Time." *American Educational Research Journal* 49(6):1048–73.

Soh, Leen-Kiat, Ashok Samal, and Gwen Nugent. 2007. "An Integrated Framework for Improved Computer Science Education: Strategies, Implementations, and Results." *Computer Science Education* 17(1):59–83.

Stets, Jan E. 2005. "Examining Emotions in Identity Theory." *Social Psychology Quarterly* 68(1):39–56.

Stets, Jan E. and Peter James Burke. 2009. *Identity Theory*. New York: Oxford University Press.

Stryker, Sheldon. 1980. *Symbolic Interactionism*. Caldwell, NJ: The Blackburn Press.

Toth, Linda S. and Linda G. Montagna. 2002. "Class Size and Achievement in Higher Education: A Summary of Current Research." *College Student Journal* 36(2):253–61.

Ulriksen, Lars, Lene Møller Madsen, and Henriette T. Holmegaard. 2010. "What Do We Know about Explanations for Drop out/Opt out among Young People from STM Higher Education Programmes?" *Studies in Science Education* 46(2):209–44.

Watt, Helen M. G. and Jacquelynne S. Eccles. 2008. *Gender and Occupational Outcomes: Longitudinal Assessments of Individual, Social, and Cultural Influences.* Washington D.C.: American Psychological Association.

Xie, Yu, Michael Fang, and Kimberlee Shauman. 2015. "Stem Education." *Annual Review of Sociology* 41:331–57.

Supplemental Appendix A: Full Survey
Fall 2018 Classroom Dynamics and STEM Pathways

Start of Block: SURVEY INSTRUCTION

Start of Block: Informed Consent

Q66 Thank you for agreeing to take part in this important survey measuring your perception of your experiences in your recent STEM class. The following question provides you with informed consent for your participation.

Q1 Emory University Consent to be a Research Subject
Title: Classroom Dynamics and STEM Pathways Principal Investigator: Jennifer Hayward
Introduction: You are invited to participate in a study that will investigate the experiences of undergraduate students (aged 18 and older) within science, technology, engineering, and mathematics (STEM) fields to identify factors affecting persistence in STEM. This form is designed to tell you everything you need to think about before you decide to consent (agree) to be in the study or not to be in the study. Results will be used to create a foundation for further research and for a Ph.D dissertation in the department of Sociology. The purpose of this study is to learn about impacts of classroom dynamics on STEM pathways. **Procedures**: Participation in this study should take about 20-25 minutes of your time. Participation will involve responding to survey questions about your experiences in the classroom and in your academic department, as well as your future career plans. **Risks and Discomforts**: The risks associated with this project are minimal. If, however, you experience discomfort you may discontinue participation at any time. You may choose not to answer any questions that may make you feel uncomfortable. I appreciate your honest answers regarding your professors. Please keep in mind that your responses can not be tracked back to you as an individual. **Benefits**: This study is not designed to benefit you directly. This study is designed to increase our understanding about factors contributing to persistence in STEM fields. **Compensation**: You will receive $5 as compensation for your time participating in this study. **Confidentiality**: All of your responses will be held confidentially. Your responses will be identified by a code number and will be kept separate from information that could identify you. Only the researcher will have access to your individual data. Agencies and university units that make rules and policy about how research is done, however, have the right to review study records in order to make sure that studies are conducted and handled correctly. These include the U.S. Office for Human Research Protections, the Institutional Review Boards reviewing the study, and their Offices of Research Compliance. I will keep the study records private to the extent allowed by law. I will perform data analysis only on aggregated responses, and no names will be associated with these analyses. All data will be stored on a password-protected and encrypted computer. Facts that might point

to you will not appear when I present this study or publish its results. **Voluntary Participation and Withdrawal from the Study**: Participation in this study is completely voluntary. You are free to decline to participate or to cease participation at any time. In addition, if you choose to participate, you may skip questions; you do not have to answer any specific question in order to answer subsequent questions. Feel free to take your time thinking about whether you would like to participate. Contact Information: If you have any questions about the content of this study please contact me at 720-933-7384 and by e-mail at j.l.hayward@emory.edu. This project is supervised by my advisor in the Department of Sociology at Emory, Dr. Karen Hegtvedt, who can be reached at 404-727-7517 or khegtve@emory.edu. You may contact the Emory Institutional Review Board (404-712-0720) or (877-503-9797) or irb@emory.edu: if you have questions about your rights as a research participant. if you have questions, concerns or complaints about the research. You may also let the IRB know about your experience as a research participant through our Research Participant Survey at http://www.surveymonkey.com/s/6ZDMW75. **Consent**: I appreciate your willingness to consider participating in this study. Agreeing to continue indicates that you consent to being a participant in this research project. If you are 18 years of age or older and would like participate in this study, please click on the “Next” button below to begin. Thank you.

○ I consent, begin the study (1)

○ I do not consent, I do not wish to participate (2)

Skip To: End of Survey If Q1 = 2

Page Break

Q2 In Fall 2018, in which of the following classes were you enrolled?

○ Biology (1)

○ Computer Science (2)

Q3 Did you at the end of the semester:

○ complete the course (1)

○ withdraw from the course (2)

○ drop the course (3)

○ take an incomplete in the course (4)

Q4 As you respond to subsequent questions, think about your Fall 2018 course specifically. The next sets of questions pertain specifically to your perceptions of the dynamics of your Fall 2018 Biology or Computer Science course.

End of Block: Informed Consent

Start of Block: Reasons for taking the biology or computer science course in Fall 2018

Q5 Since the beginning of college, which of the following people have you talked with about selecting science courses to take this year? (Check all that apply.)

- ☐ Family member(s) (1)
- ☐ Friend(s) or other student(s) (3)
- ☐ A teacher (4)
- ☐ An academic advisor (5)
- ☐ Other (6) ____

Q6 Thinking back to class registration, why did you take your biology or computer science course? (Check all that apply.)

- [ ] You really enjoy science (1)
- [ ] You are interested in the topic (2)
- [ ] It meets a school requirement (3)
- [ ] Your advisor suggested it (4)
- [ ] Encouragement from your parent(s) (5)
- [ ] Encouragement from your professor(s) (6)
- [ ] You will need it for your major/minor (8)
- [ ] You will need it for your career (10)
- [ ] You will need it for pursuing graduate/medical school (11)
- [ ] Some other reason (13)
- [ ] You don't know why you took this course (14)

Q7 Thinking about the areas in which you have taken courses while in college, indicate your favorite course domains by ranking the following areas (where your favorite area is ranked 1 - you can drag and drop options).

______ Humanities (e.g., English, Religion, History, Art History) (1)
______ Foreign Language (2)
______ Social Science (e.g., Sociology, Psychology, Anthropology, Economics, Health) (3)
______ Visual/ Performing Arts (4)
______ Mathematics + Computer Science (5)
______ Natural Sciences (e.g., Chemistry, Biology, Physics) (6)
______ Business (7)

Q8 Thinking about the most challenging week(s) you had in your biology or computer science course in Fall 2018, approximately how much time (in **hours**) did you spend on homework that week?

____

Q9 In Fall 2018, in a typical week, approximately how much time (in **hours**) do you spend on school-sponsored extracurricular activities (for example, sports, school clubs, etc.)?

____

Page Break

End of Block: Reasons for taking the biology or computer science course in Fall 2018

Start of Block: .

Q10 In your Fall 2018 biology or computer science course, please think about your professor and indicate how much you disagree or agree with the following statements as they characterized your interactions throughout the semester. My professor seemed to...

	Strongly Disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
respect students (1)	○	○	○	○	○	○	○
take steps to deal with me in a truthful manner (2)	○	○	○	○	○	○	○
treat me with kindness and consideration (3)	○	○	○	○	○	○	○
be honest and ethical in dealing with me (7)	○	○	○	○	○	○	○
be completely candid and frank with me (9)	○	○	○	○	○	○	○
treat students of all genders equally (4)	○	○	○	○	○	○	○
treat students of all races equally (5)	○	○	○	○	○	○	○
refrain from improper remarks or comments (6)	○	○	○	○	○	○	○
show a real interest in trying to be fair (8)	○	○	○	○	○	○	○

Q11 In your Fall 2018 biology or computer science course, please think about your professor and indicate how much you disagree or agree with the following statements as they characterized your interactions throughout the semester.   My professor seemed to...

	Strongly Disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
use consistent standards in evaluating my performance (2)							
give me feedback that helped me learn how well I was doing (3)							
take into account factors beyond my control (4)							
discuss plans or objectives to improve my performance (11)							
obtain accurate information about my performance (7)							
make clear what was expected of me (5)							
communicate regularly with students (1)							

provide timely information about course decisions and their implications (6)	○	○	○	○	○	○	○
be influenced by things that should not be considered (9)	○	○	○	○	○	○	○
give opportunities to express any concerns (10)	○	○	○	○	○	○	○
appear to allow his/her personal motives or biases to influence evaluation (8)	○	○	○	○	○	○	○

End of Block: .

Start of Block: I

Q12 In your Fall 2018 biology or computer science course, please think about your professor and indicate how much you disagree or agree with the following statements as they characterized your interactions throughout the semester.   My professor seemed to:

	Strongly Disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
be candid in his/her communications with me (1)	○	○	○	○	○	○	○
give me reasonable explanations regarding the procedures (3)	○	○	○	○	○	○	○
be very concerned about my welfare (5)	○	○	○	○	○	○	○
really go out of his/her way to help me (6)	○	○	○	○	○	○	○
explain routine procedures thoroughly (2)	○	○	○	○	○	○	○
communicate details in a timely manner (4)	○	○	○	○	○	○	○

Page Break

End of Block: I

Start of Block: VI

Q13 In the course of your Fall 2018 biology or computer science class, did you have the opportunity to interact directly with your professor (not the TA) for the course?

○ Yes (1)

○ No (2)

Q14 Thinking about your interactions with your professor, how much did you typically feel each of the following:

	None at all (1)	(2)	(3)	A moderate amount (4)	(5)	(6)	A great deal (7)
Excited (3)	○	○	○	○	○	○	○
Frustrated (5)	○	○	○	○	○	○	○
Worried (8)	○	○	○	○	○	○	○
Encouraged (10)	○	○	○	○	○	○	○
Disappointed (11)	○	○	○	○	○	○	○

Page Break

Q15 In the course of your Fall 2018 biology or computer science class, did you have the opportunity to interact directly with your TA(s) for the course?

○ Yes (1)

○ No (2)

Q16 In your biology or computer science course in Fall 2018, who do you feel you interacted with more?

○ The professor of your course (1)

○ The TA(s) of your course (2)

○ Other (3) ____

Q17 During the course of your Fall 2018 biology or computer science class, how much do each of the following characterize your impressions of the TA(s) in general?

	Not at all (1)	(2)	(3)	A moderate amount (4)	(5)	(6)	A great deal (7)
Approachable (1)	○	○	○	○	○	○	○
Helpful (2)	○	○	○	○	○	○	○
Effective (3)	○	○	○	○	○	○	○
Competent (4)	○	○	○	○	○	○	○

Q18 What was the gender of the TA with whom you interacted most frequently?

○ Man (1)

○ Woman (2)

○ Other (4) ____

○ N/A because interacted equally with all TAs (3)

End of Block: VI

Start of Block: .

Q19 Now, thinking about the grades you received in your biology or computer science course, how much do you disagree or agree with the following:

Q20 Overall, how unfair or fair do you believe your grades were?

	Very unfair (1)	Unfair (2)	Somewhat unfair (3)	Neither fair or unfair (4)	Somewhat fair (5)	Fair (6)	Very fair (7)
Final grades (1)	○	○	○	○	○	○	○
Lab grades (2)	○	○	○	○	○	○	○
Quiz grades (3)	○	○	○	○	○	○	○
Exam grades (4)	○	○	○	○	○	○	○

Q21 My grades were fair...

	Strongly Disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
Considering the responsibilities I had (1)	○	○	○	○	○	○	○
For the amount of effort I put forth (2)	○	○	○	○	○	○	○
Considering the stress I experienced (3)	○	○	○	○	○	○	○

Q22 How much did you typically feel each of the following about your biology or computer science class in general?

	None at all (1)	(2)	(3)	A moderate amount (4)	(5)	(6)	A great deal (7)
Happy (1)	○	○	○	○	○	○	○
Excited (2)	○	○	○	○	○	○	○
Frustrated (3)	○	○	○	○	○	○	○
Encouraged (4)	○	○	○	○	○	○	○
Disappointed (5)	○	○	○	○	○	○	○

Page Break

Q23 In general to what extent did you see your biology or computer science course as...

	Not at all (1)	(2)	(3)	A moderate amount (4)	(5)	(6)	A great deal (7)
a waste of time (2)	○	○	○	○	○	○	○
important to your future career (6)	○	○	○	○	○	○	○
the sort of work you expect after college (4)	○	○	○	○	○	○	○
worth taking (5)	○	○	○	○	○	○	○
a course you would take again (7)	○	○	○	○	○	○	○

Q24 Based on your encounters with representatives of the departments sponsoring the Fall 2018 biology or computer science course you took, how much do each of the following statements characterize your impression of the department? The biology or computer science department seems to...

	Don't know (1)	Not at all (2)	(3)	(4)	A moderate amount (5)	(6)	(7)	A great deal (8)
Care about my opinions (1)	○	○	○	○	○	○	○	○
Care about my well-being (2)	○	○	○	○	○	○	○	○
Consider my goals and values (3)	○	○	○	○	○	○	○	○
Provide help when I have a problem (4)	○	○	○	○	○	○	○	○
Show very little concern for me (5)	○	○	○	○	○	○	○	○
Show very little concern for introductory students (6)	○	○	○	○	○	○	○	○

Q25 To what extent would you recommend...

	Not at all (1)	(2)	(3)	A moderate amount (4)	(5)	(8)	A great deal (9)
this department to others (1)	○	○	○	○	○	○	○
this course to others (2)	○	○	○	○	○	○	○
this professor to others (3)	○	○	○	○	○	○	○

Page Break

Q26 How likely are you to take another class in a Science, Technology, Engineering, or Mathematics (STEM) related field?

	Extremely unlikely (1)	Moderately unlikely (2)	Slightly unlikely (3)	Neither likely nor unlikely (4)	Slightly likely (5)	Moderately likely (6)	Extremely likely (7)
(1)	○	○	○	○	○	○	○

Q27 Thinking about your grades *across all of your classes*, how much do you disagree or agree with each of the following:

	Strongly Disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
Good grades are really important to me (1)	○	○	○	○	○	○	○
My grades accurately reflect my skills (2)	○	○	○	○	○	○	○
How much effort I put into my work is reflected in my grades (6)	○	○	○	○	○	○	○
How much work I get done is reflected in my grades (3)	○	○	○	○	○	○	○
How many errors I make in my work is reflected in my grades (4)	○	○	○	○	○	○	○
Whether or not my professor likes me contributes to my grades (5)	○	○	○	○	○	○	○

I consider my work load for the course to be quite fair (7)	○	○	○	○	○	○	○

End of Block: .

Start of Block: Block 12

Q58 In the next section, think about your interactions with other students in your Fall 2018 biology or computer science course.

Q63 Other students in my class seemed to...

	Strongly disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
respect me (1)	o	o	o	o	o	o	o
treat me as an equal (2)	o	o	o	o	o	o	o
treat me with kindness and consideration (3)	o	o	o	o	o	o	o
listen to my ideas (4)	o	o	o	o	o	o	o
take into account my ideas on group projects (9)	o	o	o	o	o	o	o
be very concerned about my welfare (5)	o	o	o	o	o	o	o
provide help when I have a problem (6)	o	o	o	o	o	o	o
treat me in an unbiased way (10)	o	o	o	o	o	o	o

Q64 How would you characterize the gender composition of your Fall 2018 biology or computer science course?

○ Predominantly men (more than 80%) (1)

○ Mostly men (about 60-79%) (2)

○ About balanced between men and women (3)

○ Mostly women (about 60-79%) (4)

○ Predominantly women (more than 80%) (5)

End of Block: Block 12

Start of Block: Identity

Q28 In the next section, think about yourself.

Q29 How much do you disagree or agree with each of the following:

	Strongly Disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I see myself as a math person (1)	○	○	○	○	○	○	○
I see myself as a science person (3)	○	○	○	○	○	○	○
I see myself as a humanities person (9)	○	○	○	○	○	○	○
I see myself as a social science person (10)	○	○	○	○	○	○	○
I would enjoy working in a research lab (6)	○	○	○	○	○	○	○
I enjoy scientific ways of thinking (7)	○	○	○	○	○	○	○
I enjoy the subject matter of science (8)	○	○	○	○	○	○	○
I would be a disappointment to others if I fail as a science student (5)	○	○	○	○	○	○	○

Others see me as a math person (2)	○	○	○	○	○	○	○
Others see me as a science person (4)	○	○	○	○	○	○	○

Q30

	Not at all (1)	(2)	(3)	A moderate amount (4)	(5)	(6)	Very Much (7)
How interested are you in going into a field which is not science and technology related? (1)	○	○	○	○	○	○	○
You meet someone new. How important is it to you that in the course of conversation you mention that you are a science student? (2)	○	○	○	○	○	○	○
To know you as you really are, how important is it to know that you are a science student? (3)	○	○	○	○	○	○	○

Page Break

Q31 Thinking about your math and science activities, how much do you disagree or agree:

	Strongly Disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
For me, being good in math is very important (1)	○	○	○	○	○	○	○
For me, being good in science is very important (2)	○	○	○	○	○	○	○
Compared to most of my other activities, it is very important to be good at math (3)	○	○	○	○	○	○	○
Compared to most of my other activities, it is very important to be good at science (4)	○	○	○	○	○	○	○
In general, I find working on math assignments very interesting (5)	○	○	○	○	○	○	○

In general, I find working on science assignments very interesting (6)	○	○	○	○	○	○	○

Q32
How much have other people encouraged you to pursue a career in science, technology, engineering, or mathematics (STEM)?

	Not at all (1)	(2)	(3)	A moderate amount (4)	(5)	(6)	Very Much (7)
Family Member(s) (1)	○	○	○	○	○	○	○
Friend(s) or other student(s) (2)	○	○	○	○	○	○	○
Teacher(s) (3)	○	○	○	○	○	○	○

Q33

	Not at all (1)	(2)	(3)	A moderate amount (4)	(5)	(6)	Very upset (7)
If someone said, ‘You have no right to call yourself a science student’, how upset would you be?” (1)	○	○	○	○	○	○	○

Q34 Please indicate if you have received any of the following forms of recognition in high school or college in your pursuit of scientific endeavors (check all that apply):

- ☐ Awards (1)
- ☐ Selected to work in a lab/as a research assistant at your university (2)
- ☐ Selected to work in a lab/as a research assistant at another institution (7)
- ☐ Selected as a teaching assistant (3)
- ☐ Asked to tutor others (4)
- ☐ Secured grant funding (5)
- ☐ Co-authored a publication or presentation (6)

End of Block: Identity

Start of Block: Kinds of recognition

Q35 How much do you disagree or agree with each of the following statements:

	Strongly Disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
I expect to do well in science courses (1)	○	○	○	○	○	○	○
I will be good at learning something new in science (2)	○	○	○	○	○	○	○

Q36 How much do you disagree or agree with the following:

	Strongly Disagree (1)	Disagree (2)	Somewhat disagree (3)	Neither agree nor disagree (4)	Somewhat agree (5)	Agree (6)	Strongly agree (7)
People say I am right in placing importance on being a science student (1)	○	○	○	○	○	○	○
I would miss my peers if I were no longer a science student (2)	○	○	○	○	○	○	○
I would no longer see a lot of my peers if I were no longer a science student (3)	○	○	○	○	○	○	○
Studying in school rarely pays off later with good jobs (4)	○	○	○	○	○	○	○

End of Block: Kinds of recognition

Start of Block: x

Q37 Think ahead to your future, beyond college.As things stand now, how far do you think you will get in school?

- ○ Start but not complete a Bachelor's degree (1)
- ○ Complete a Bachelor's degree (2)
- ○ Start but not complete a Master's degree or equivalent (3)
- ○ Complete a Master's degree or equivalent (4)
- ○ Start but not complete a Ph.D., M.D., law degree, or other high level professional degree (5)
- ○ Complete a Ph.D., M.D., law degree, or other high level professional degree (6)
- ○ Don't know (7)

Q38 As things stand now, what is the job or occupation that you expect or plan to have at age 30?

____

Q39

	Not at all (1)	(2)	(3)	A moderate amount (4)	(5)	(6)	A great deal (7)
How much have you thought about this occupational choice? (1)	○	○	○	○	○	○	○

Q40 Altogether, how many of your close friends have left school before graduating college? (Do not include those who have transferred to another school.)

- ○ None of them (1)
- ○ Some of them (2)
- ○ Most of them (3)
- ○ All of them (4)

End of Block: x

Start of Block: x

Q41 How important is each of the following to you in your life?

	N/A (8)	Not at all important (1)	(2)	(3)	Somewhat important (4)	(5)	(6)	Very Important (7)
Being successful in my line of work (1)	○	○	○	○	○	○	○	○
Finding the right person to marry and having a happy family life (2)	○	○	○	○	○	○	○	○
Having lots of money (3)	○	○	○	○	○	○	○	○
Having strong friendships (4)	○	○	○	○	○	○	○	○
Being able to find steady work (5)	○	○	○	○	○	○	○	○
Helping other people in my community (6)	○	○	○	○	○	○	○	○
Being able to give my children better opportunities than I've had (7)	○	○	○	○	○	○	○	○
Working to correct social and economic inequalities (8)	○	○	○	○	○	○	○	○

Having children (9)	○	○	○	○	○	○	○	○
Having leisure time to enjoy my own interests (10)	○	○	○	○	○	○	○	○
Becoming an expert in my field of work (11)	○	○	○	○	○	○	○	○
Getting a good education (12)	○	○	○	○	○	○	○	○

Page Break

End of Block: x

Start of Block: This last set of questions focuses on your background.

Q42 Were you ever in any of the following kinds of courses or programs in high school? (Check all that apply)

▢ Advanced Placement (AP) (1)

▢ International Baccalaureate (IB) (2)

▢ Honors Courses (3)

▢ Courses or a program which you take at a separate area or regional vocational school part-time (4)

▢ Remedial English (5)

▢ Remedial math (6)

▢ Bilingual or bicultural education (7)

▢ English as a Second Langauge (ESL) (8)

▢ Dropout prevention, Alternative or Stay-in-School Program (9)

▢ Special Education Program (10)

▢ Distance learning course (11)

▢ Career academy (12)

☐ Special program to help students plan or prepare for college (13)

Q43 What is your current or intended academic major?

____

Q44 What if any is your current or intended academic 2nd major or minor?

____

Q45 What is your GPA?

____

Q46 Do you identify as:

○ A man (1)

○ A woman (2)

○ Other (3) ____

Q47 Select one or more of the following to describe your race. (Mark all that apply)

- ☐ White (1)
- ☐ Black/African American (2)
- ☐ Asian (3)
- ☐ Native Hawaiian or Other Pacific Islander (4)
- ☐ American Indian or Alaska Native (5)
- ☐ Other (6) ____

Q48 Are you Hispanic or Latino/Latina?

- ○ Yes (1)
- ○ No (2)

Q49 Are you an International Student?

- ○ Yes (1)
- ○ No (3)

Skip To: Q51 If Q49 = 3

Q50 Are you an F1 visa holder?

- ◯ Yes (1)
- ◯ No (2)
- ◯ Other (3) ____

Q51 How many years have you been in college?

- ◯ 1 (1)
- ◯ 2 (2)
- ◯ 3 (3)
- ◯ 4 (4)
- ◯ 5+ (5)

Q52 Do you have any need-based financial aid?

- ◯ Yes (1)
- ◯ No (2)
- ◯ Don't know (3)

Q65 What is your estimated household annual income?

- ○ Less than $25,000 (1)
- ○ $25,001-$50,000 (2)
- ○ $50,001 - $75,000 (3)
- ○ $100,001 - $150,000 (4)
- ○ $150,001 - $200,000 (5)
- ○ $200,001 - $250,000 (6)
- ○ More than $250,000 (7)

Q53 What would it take to keep you in a science track?

____

Q54 Thank you!
Please click here to take you to a separate site (not linked to your survey responses) to provide information to receive compensation ($5) for your time.

End of Block: This last set of questions focuses on your background.