Classroom Culture Clash:

Exploring Classroom Culture and Persistence for Undergraduate Students in Introductory Science, Technology, Engineering, and Mathematics Courses at Two Public Universities

By

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A dissertation submitted in partial fulfillment of

the requirements for the degree of

Doctor of Philosophy

(Educational Psychology)

at the

UNIVERSITY OF WISCONSIN-MADISON

2017

Date of final oral examination: 05/02/2016

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Table of Contents

List of Tables

List of Figures

Dedication

To my parents, who always told me:

Press On!
Nothing in the world can take the place of persistence.
Talent will not; nothing is more common than unsuccessful men with talent.
Genius will not; unrewarded genius is almost a proverb.
Education will not; the world is full of educated derelicts.
Persistence and determination alone are omnipotent.
The slogan 'Press On!' has solved and always will solve the problems of the human race.
– J. Calvin Coolidge

. . . thank you for giving me everything I needed to persist in following my dreams.

Acknowledgements

It takes a village to raise a child, but it takes so many more to raise a scholar. I am filled with gratitude for my dissertation committee members and the countless others who have shaped my academic career, and here I hope to name and thank just a few:

Thank you to my parents, Jane and Mark Vivyan, who have believed in me since the moment I came into the world. Thanks also to my younger sister, Terri Vivyan, who is the only person who truly understands why I am who I am because she has lived through our childhood alongside me. Despite the fact that my education has taken me farther from my family, their unwavering support has been my one constant.

Thank you to my extended family for all of their love, support, and FaceTime calls while my studies have prevented me from attending family gatherings. Thanks especially my great grandfather Adolph Dascenzo, my godfather Dennis Dascenzo, my uncle Ric Vivyan, and my aunt Kelley Vivyan for their generous financial support.

Thank you to Todd Lipa, Barry Checkoway, Susan Zurvalec, and the countless community leaders and educators who have developed my interest in social justice. I could not have tackled this dissertation without the passion that you all led me to find.

Finally, thank you to the *Talking about Leaving – Revisited* team, especially Mark Connolly, Joseph Ferrare, and Ross Benbow, for bringing me onto the project in my first year of graduate school and for supporting my use of the project's data for this study. I am so grateful for this job and your mentorship in my research career.

Abstract

The purpose of this study was to explore the classroom culture of introductory science, technology, engineering, and mathematics (STEM) courses at two public universities. The author describes the classroom culture of introductory STEM courses, delineates the factors that contribute to this culture, and examines the possible effects of classroom culture, cultural congruity, and cultural incongruity on student thinking about persistence and switching decisions. Specifically, this study was focused on exploring the effects that cultural congruity and incongruity in the classroom may have on student thinking about persistence and switching decisions among STEM majors, particularly for underrepresented students. Drawing upon field theory and using qualitative methodology, the author explores classroom culture through the analysis of faculty member individual interviews and student focus-group interviews from a sample of instructors and students at two public universities. Results indicate that students and instructors experience a weed-out and competitive classroom culture in introductory STEM courses. This culture is developed through student, instructor, class, department/institution, and social factors. Weed-out and competitive culture is viewed negatively by the sample as a whole, and contributes to a clash between the preferred and actual classroom culture for many students, particularly those currently underrepresented in STEM. Findings point to possible intervention points to improve classroom culture in introductory STEM courses for the purposes of increasing persistence.

Keywords: classroom culture, STEM, persistence, switching

Chapter 1: Introduction and Review of Literature

Introduction

The purpose of this study was to explore the classroom culture of introductory science, technology, engineering, and mathematics (STEM) courses at two public universities. The study sought to describe the classroom culture of introductory STEM courses, delineate the factors that contribute to this culture, and examine the possible effects of classroom culture, cultural congruity, and cultural incongruity on student thinking about persistence and switching decisions, particularly for underrepresented students.

STEM fields are consistently linked to individual and national economic prosperity, innovation, and esteem (National Science Foundation [NSF], 2013). Educational researchers and policy makers regularly talk about the need to encourage more students to pursue and persist in these fields. Nevertheless, women and several racial and ethnic groups continue to be underrepresented in STEM majors while White males remain overrepresented (NSF, 2013). These gendered and racial patterns of STEM degree attainment are cause for concern.

Many factors influence decisions to choose and persist in STEM fields. Encountering the culture of an educational institution for the first time is often a difficult, overwhelming experience for undergraduate students from underrepresented groups (e.g., Latino students; Fiske, 1988). Encountering the culture of a STEM classroom may be particularly overwhelming. More specifically, cultural congruity (Gloria, 2001; Gloria & Kurpius, 1996) between the educational environment and the individual student's preferences may be related to student thinking about persistence and switching decisions.

A more thorough understanding of STEM classroom culture, the factors that influence this culture, and its relationship to student thinking about persistence and switching decisions in STEM will help researchers and policymakers to better understand how to promote persistence among all students in STEM, particularly those who continue to be underrepresented.

Review of Literature

Overview. The overarching question addressed in this literature review is: *How does classroom culture affect persistence among underrepresented students in STEM?* The following review synthesizes research on students who remain underrepresented in STEM majors and careers. First, key concepts and terms are defined. Next, evidence of and reasons for underrepresentation are explored. This review integrates findings from multiple studies, which suggest that underrepresented students may experience (or could potentially experience) cultural incongruity in introductory STEM courses. The nature of this cultural congruity and incongruity is discussed. Finally, the possible effects of cultural incongruity on persistence are addressed, and gaps in the literature related to cultural congruity and incongruity are highlighted, setting the stage for the present study.

Key concepts. The current literature lacks clear and consistent definitions of key terms, such as *classroom culture* and *cultural incongruity*. Therefore, in the following paragraphs, key concepts are defined based on multiple, integrated research perspectives.

Classroom culture. Every classroom constructs its own culture through the interactions of all participants, including students and instructors (Zastavker, Darer, & Kessler, 2013). This culture might be visible or invisible, well defined or vague. No matter the culture, it has a direct impact on teaching and learning in the classroom.

Classroom climate is one component of classroom culture (Fraser, 1989). For the purposes of this review, classroom climate is defined as the pedagogical features and interpersonal qualities of a classroom. For example, the classroom climate might be one of tolerance toward diversity or one permeated by prejudice and discrimination (Cabrera, Colbeck, & Terenzini, 2001). The actions and interactions within the classroom contribute to the development of classroom climate.

Classroom culture, however, refers to both the classroom climate and the system of meanings that students and instructors construct in relation to classroom practices, interactions, and artifacts. That is, classroom culture includes students' and instructors' thoughts, feelings, beliefs, and behaviors in response to the classroom climate.

Cultural congruity and incongruity. *Cultural congruity* can be defined as the balance between the cultural identities and preferences of a particular group (e.g., Latin@ students, women, etc.) and the cultural identities and preferences of the dominant group (e.g., White males) in any given institutional environment (e.g., classrooms, workplaces, etc.). Individuals identifying with two or more cultures (e.g., Latin@ mathematicians) may experience some level of incongruity if the cultures are different in values, beliefs, and expectations for behaviors (Gloria & Kurpius, 1996). One student described this inner conflict rather concisely: "We have pressures on us not to lose our culture, while maintaining a status quo in this culture. That's a big pressure," (Fiske, 1988, p. 31). Ferrare and Hora (2012) posit that students and instructors hold a cultural model for how people and objects fit together in the classroom. Sometimes these cultural models work well together, and sometimes they are in conflict. When the latter is present, students experience what is termed *cultural incongruity*.

Fiske (1988) first described cultural incongruity in a study depicting experiences of several Hispanic students at undergraduate institutions in the United States. Fiske followed a number of Hispanic college students at well-known universities (e.g., Arizona State University, University of California- Los Angeles, Stanford University, etc.). Using brief quotations from interviews with these students, the author concluded that "culture shock" is a harsh reality for a large proportion of Hispanic college students at U.S. institutions of higher education.

Cultural congruity and incongruity are typically measured at the institutional level. Gloria and Kurpius (1996) developed the *Cultural Congruity Scale* (CCS) to measure levels of cultural congruity and incongruity at institutions of higher education. Items on the CCS focus on the experiences of racial and ethnic minority students that are rated on a Likert scale from 1 (*not at all*) to 7 (*a great deal*). Sample items include "I feel that I have to change myself to fit in at school," and "I feel accepted at school as an ethnic minority." Across a variety of majors, White undergraduate students report higher levels of cultural congruity than do students from underrepresented racial and ethnic groups (Gloria, 2001).

Recent research supports the idea that cultural congruity is an important factor for a number of undergraduate outcomes. For example, a recent study suggests that women are more likely than men to be interested in careers that are congruent with their endorsement of communal goals (Diekman, Brown, Johnston, & Clark, 2010). That is, the perceived feminine ideal of helping others and improving one's community makes women less likely to choose STEM careers. The results of another study suggest that Latin@ students perform better academically when they have cultural congruity within their chosen academic major (Cole & Espinoza, 2008). Student outcomes such as major choice and persistence may all be affected by cultural congruity and incongruity. Among the many student outcomes associated with cultural congruity and incongruity, student thoughts about persistence and switching are important because these decisions have long-term impact on students' academic and professional trajectories.

Persistence and switching. *Persistence* in STEM is best defined as continuing on the path to complete a degree in science, engineering, technology, and/or mathematics. It may also be described as the absence of *switching* to a non-STEM major or dropping out of higher education. Currently, STEM recruitment programs targeting White women and ALANA students are more widespread than are retention or persistence programs (Bayer Corporation, 2012). Researchers urge colleges and universities to look beyond recruitment and enrollment to address issues of retention, persistence and graduation within these groups (Palmer, Maramba, & Dancy, 2011).

STEM. *STEM* is an acronym referring to the academic disciplines and career paths in science, technology, engineering, and mathematics. "Science" includes physical and biological sciences. "Technology" includes the fields of computer science and information technology. "Engineering" includes chemical, civil, electrical, industrial, materials, and mechanical engineering. Finally, "mathematics" includes calculus and statistics courses as well as mathematics majors. Laypersons and researchers alike believe that STEM fields have an especially unique culture when compared to other areas of study (e.g., social sciences; Seymour & Hewitt, 1997). Unfortunately, the classroom-level culture in STEM has not been clearly defined in the literature; therefore, a richer understanding of STEM classroom culture, its influences, and its effects, is needed.

Introductory courses. Throughout the literature, introductory STEM courses are referred to as introductory courses (e.g., Eagan, Herrera, Sharkness, Hurtado, & Chang, 2011), barrier courses (e.g., Suresh, 2006), and gateway courses (e.g., Davies-Vollum & Greengrove, 2010). For the purposes of this study, the term *introductory courses* is used to refer to foundational courses considered to play important roles in the early stages of a degree program. Introductory STEM courses are foundation courses required for graduation from one or more STEM majors at an institution of higher education. Examples of introductory STEM courses include Calculus 1, Introduction to Programming, General Chemistry, etc.

Underrepresentation in STEM. Despite recent efforts to encourage underrepresented students to graduate from STEM fields, disparities remain in both rates of enrollment and persistence between men and women, and between White students and other racial/ethnic groups.

Who is underrepresented in STEM? Women and African American, Latino/a American, Asian American and Native American (ALANA) students are underrepresented in STEM because they constitute smaller percentages of STEM degree recipients and STEM professionals than they do of the overall population (Byars-Winston, Estrada, & Howard, 2008; NSF, 2013). Underrepresentation in STEM is linked with multiple social factors and identities. Researchers often point to gender and racial/ethnic identities as important factors in STEM persistence. Economic and class differences also play a role in choosing STEM careers among undergraduate students (Wilson, Iyengar, Pang, Warner, & Luces, 2012). Oppland (2010) found that students' social identities (racial/ethnic, gender, and/or socioeconomic status), participatory trajectories (persistence or switching), and learning opportunities were all interrelated. Additionally, different combinations of the above identities might influence STEM persistence in distinct ways.

ALANA women represent a unique group that experiences the challenges of both female gender and underrepresented racial/ethnic status of a chosen career in STEM (Anonymous, 2011). In describing the experiences of ALANA women in STEM fields, Malcom and colleagues (1976) used the term "double bind" to convey that these individuals face oppression and discrimination based on both their gender and their racial/ethnic identity. This "double bind" occurs as the factors of gender and race/ethnicity intersect to produce distinct experiences for ALANA women in STEM classrooms (Ong, Wright, Espinosa, & Orfield, 2011).

Why does underrepresentation in STEM matter? Underrepresentation in STEM is problematic because it limits the scope of knowledge produced in STEM fields and produces unethical power hierarchies in educational and occupational spheres. The mere fact of underrepresentation does not necessarily indicate cultural incongruity. The two, however, are certainly related. If, for example, cultural incongruity leads to feelings of alienation, these feelings can decrease students' efficacy expectations and, in turn, their participation in STEM fields (Adleman & Enguidanos, 1995).

Underrepresentation in STEM prohibits equal opportunity, or equal access, to study and work for all individuals (Blickenstaff, 2005). Research suggests that structural differentiation in educational and occupational spheres contributes to social class inequality (Roksa, 2011). STEM fields are considered lucrative and respectable areas in which to work (NSF, 2013). Furthermore, STEM knowledge and skills also contribute to success in many rewarding non-STEM careers (National Science Board, 2015). Thus, promoting persistence for White women and ALANA students in STEM fields is a step toward equity of opportunity, respect, and income.

A substantial number of intelligent, talented White women and ALANA students are choosing fields other than STEM, and our societal institutions and local communities are missing out on their potential contributions (Blickenstaff, 2005). Many STEM department heads agree that increasing the number of White women and ALANA students in STEM education is an important national priority (Bayer Corporation, 2012). Additionally, access and success among underrepresented populations in STEM are critically important to U.S. economic competitiveness in the global economy as well as equity in higher education (Palmer et al., 2011). STEM industries that rely on quality graduates are faced with a lack of eligible candidates, and underrepresented students are missing out on the opportunity to find success in STEM classrooms and careers. Thus, to remain economically and academically competitive and equitable, it is important to promote persistence among all students.

Greater diversity of perspectives in STEM fields can also increase the collective knowledge base (Blickenstaff, 2005). Diversity is desired both in educational institutions and in the workplace, as diverse world views can be particularly useful in solving complex problems (Page, 2008). Evidence suggests that the relationship between diversity and student problem-solving skills is significant even at the classroom level (Terenzini, Cabrera, Colbeck, Bjorklund, & Parente, 2001). In STEM fields, racial/ethnic as well as gender diversity can bring fresh viewpoints and unique ideas to promote problem solving and innovation (Canetto & Byars-Winston, 2011).

Finally, students who are not underrepresented in STEM are also affected by disproportionality. Whether overt or subtle, differential treatment based on gender, race, or ethnic background can be damaging to individual students and the educational process as a whole. For example, men who experience STEM courses that are inhospitable to women may find it difficult to perceive women as equal peers, to work with them in collaborative learning situations, and to offer them support as colleagues in academic or professional settings (Hall & Sandler, 1982). A diverse student body is a first step toward the broader goal of inclusion for all students (Tienda, 2013).

What has been done to help underrepresented students in STEM fields? In the last 20 years, a number of programs have emerged to encourage more women to participate in STEM fields (Blickenstaff, 2005). Institutions such as Oberlin College, Hope College, the University of Wisconsin, the University of Delaware, Harvard University, Yale University, and the University of California at Berkeley have conducted research to determine how adequately the institution meets the needs of its women students (Seymour & Hewitt, 1997). Findings suggest that women have different preferences for STEM classrooms than do men (Seymour & Hewitt). Institutional changes and programs for women have been developed to encourage women in these fields, and program evaluations suggest that women in STEM rate these programs positively and, if they participate, are more likely to persist in a STEM major (Tsui, 2007).

Successful programs also exist to support the enrollment of ALANA students in STEM fields at the University of Michigan, Rochester Institute of Technology, University of Arizona, and New Jersey Institute of Technology; these initiatives include summer bridge programs, mentoring, research experience, tutoring, career counseling and awareness, learning centers, workshops and seminars, academic advising, financial support, and curriculum and instructional reform (Tsui, 2007). The implementation of these programs has been linked to an increase in grade point average (GPA) and in graduation rates for STEM majors at historically black colleges and universities (Palmer et al., 2011). Despite providing resources for ALANA students, however, these types of programs do not directly address what happens (or does not happen) in STEM classrooms to promote persistence.

Evidence of and reasons for underrepresentation. Scholars agree that White women and ALANA students are underrepresented in STEM fields. The evidence and possible reasons for this disproportionality, however, may vary.

Underrepresentation of women in STEM. Women constituted slightly more than half of all U.S. residents in 2010 (NSF, 2013), and make up the majority of the university student population in most industrialized countries (Delisle, Guay, Senécal, & Larose, 2009). At the same time, women in the U.S. earn less than 50% of bachelor's degrees in mathematics and physical sciences, and less than 30% in engineering and technology (NSF). Unfortunately, equality in STEM degree completion has not yet been achieved.

Consistent with the above findings, research demonstrates that women are more likely to graduate with degrees in education, arts, humanities, social sciences, and law, whereas men are more likely to graduate from natural sciences, mathematics, and engineering departments (Bradley, 2000). This trend occurs across the globe and has changed surprisingly little from 1965 through 1990 despite increased efforts to include women in traditionally "masculine" fields (Bradley, 2000). Gender segregation exists in most majors, but has historically been most evident in the STEM fields (Sax, Jacobs, & Riggers, 2010). Women have made greater enrollment strides in STEM fields compared to underrepresented racial and ethnic groups, but still face many challenges (Bayer Corporation, 2012).

The literature offers several explanations for women being more likely to leave STEM fields (Blickenstaff, 2005). These include standardized testing discrepancies, biological differences, social influence, previous preparation, potential earnings, individual preferences, enjoyment, goal attainment, influence of parents and loved ones, perceived amount of work, lack of role models, structure of the majors, and educational goals (Clewell & Campbell, 2002; Dickson, 2010; Eccles, 2007; Mann & DiPrete, 2013). Most likely, a combination of multiple factors may dissuade women from pursuing STEM majors and careers (Mann & DiPrete, 2013).

A testing-based theory of underrepresentation attributes gender differences in STEM to standardized test scores. When test data are disaggregated by gender, girls tend to score lower than do boys on mathematics and science subtests (Ceci, Williams, & Barnett, 2009). Additionally, more men than women score extremely well on "mathematics gatekeeper tests" (e.g., SAT-Mathematics, Graduate Record Examinations-Quantitative Reasoning sections; Ceci et al., 2009). These score discrepancies may be the result of biased test items, stereotype threat, societal bias against the achievement of women, or any combination of these factors (Clewell & Campbell, 2002). No matter the cause, the results of these standardized tests may impact the likelihood that women will choose and persist in STEM majors.

Some claim there are biological gender differences that affect STEM participation and persistence among women (Clewell & Campbell, 2002). Such gender-difference theories suggest that women are inferior to men in certain cognitive skills and specific mathematical and scientific abilities. They also suggest that these differences can never be changed, rendering programs or efforts to improve outcomes for women futile. Biological evidence for the underrepresentation of women in STEM fields, however, is both contradictory and inconclusive (Ceci et al., 2009).

A large body of research suggests that females' perceptions of STEM and themselves as practitioners in STEM profoundly influence decisions to participate (or not to participate) in STEM fields (Clewell & Campbell, 2002). A lack of positive experiences with science and mathematics in childhood can affect later educational and career decisions (Blickenstaff, 2005). These social-psychological theories suggest that teachers, counselors, peers, parents, the general public, and the media can have a substantial impact on the way STEM fields are perceived as being suitable for women.

There exists cultural and social pressure for girls and women to conform to traditional gender roles in their educational, professional, and personal lives (Blickenstaff, 2005), and these expectations often limit women's career choices to traditional roles (Malcom et al., 1976). For example, math-proficient women disproportionately prefer careers in non-math-intensive fields and are more likely than men to leave these careers at all time points (Ceci et al., 2009). These career choices often have nothing to do with a lack of ability. Women with high math competence are more likely to also have high verbal confidence, which leads to a greater choice of professions (Ceci et al.). Additionally, because women are not traditionally expected to be breadwinners, they may experience greater flexibility in exploring careers that are not as well paid or prestigious as those in STEM (Seymour & Hewitt, 1997). Finally, within the STEM workplace, many women are penalized for having children when it comes time for a promotion, thus discouraging them from pursuing STEM careers (Ceci et al.).

Women self-report lower scores in spatial ability and computer skills than do men (Jackson, Gardner, & Sullivan, 1993). Among engineering students, women have lower self-ratings of their overall academic ability as well as mathematics, science, writing, problem-solving, and public-speaking abilities compared to men (Jackson et al., 1993). Research suggests that gender differences in self-confidence, interests, and orientations account for at least part of the gender gap in STEM fields (Sax et al., 2010).

Researchers also suggest that girls often lack academic preparation for a science major/career (Blickenstaff, 2005). Differences in high school preparation explain substantial variation in the selection of a STEM or non-STEM major (Riegle-Crumb & King, 2011). Lack of previous mastery experiences in relevant academic areas could certainly affect women's decision not to persist in STEM at the undergraduate level.

GPA is a strong predictor for persistence in STEM fields. Women tend to have higher grades than do men in high school, which facilitates entry into STEM fields (Sax et al., 2010). Lower academic self-assessments among women, however, continue to impede their pursuit of STEM majors and careers (Sax et al., 2010). Men report higher mathematics self-efficacy than do women, but there are no statistically significant gender differences in mathematics grades (Peters, 2013). Thus, despite the fact that GPA is a strong predictor for persistence, women often look to other indicators of math and science success. Precollege socialization might leave a negative attitude toward math and science that many women do not overcome (Seymour & Hewitt, 1997).

Underrepresentation of ALANA students in STEM. Both initial major choice and the probability of switching majors differ among racial and ethnic groups (Dickson, 2010). In 2010, Blacks constituted 12% of the U.S. population, Latin@s 16%, and other racial groups (including Native Americans and Southeast Asians) 3% of the population (NSF, 2013). Despite steady increases in undergraduate degree completion in the overall population of college students, African American, Latin@, South East Asian, and Native American students are significantly less likely to complete degrees in STEM fields when compared to their peers (Byars-Winston et al., 2008).

There has been a rise in the number of technology degrees earned by underrepresented racial/ethnic groups since 1991; since 2000, however, engineering and physical sciences have remained flat, and mathematics has dropped (NSF, 2013). Black men have historically had the lowest academic performance, and they continue to be underrepresented in higher education, particularly in STEM fields (Hrabowski III & Maton, 2009). ALANA students, remain an underrepresented group in STEM majors and careers.

Many ALANA students seek a sense of community, particularly during their college years. Research suggests that ALANA students feel disengaged in STEM programs that fail to foster a sense of community among faculty, students, alumni, and professionals (Palmer et al., 2011).   Some institutions have resources and programs to help ALANA students, particularly in the STEM fields, such as mentoring, advising, and orientation programs. For many ALANA students, however, these types of resources are not available at their institutions; this is cited as a common reason for ALANA students to switch out of STEM majors (Seymour & Hewitt, 1997).

Differences in precollege academic preparation explain part of the underrepresentation of ALANA students in STEM (Smyth & McArdle, 2004). For instance, ALANA students are more likely to inappropriately choose a STEM major than are White students; that is, ALANA students who choose a STEM major are more likely to be underprepared compared to their White peers (Seymour & Hewitt, 1997). Approximately one-quarter of ALANA students cite inadequate high school preparation as a reason for switching out of STEM, whereas only about 10% of White students do so (Seymour & Hewitt, 1997). In addition to being underprepared, many ALANA students experienced academic success in high school and are overconfident in their ability to experience success in a STEM major as an undergraduate student (Seymour & Hewitt, 1997). Experiences with academic struggle and failure may certainly contribute to disproportional dropout rates for ALANA students in STEM.

Many ALANA students also face the dual challenge of persisting in STEM and persisting at primarily White educational institutions. Building an identity as a scientist is different from building an identity as a member of a racial/ethnic minority group at a primarily White institution (Malone & Barabino, 2009). ALANA students must, therefore, develop both their professional identity and their racial/ethnic identity. The complicated balance between these identities could certainly pose additional challenges for ALANA students persisting in STEM majors.

Underrepresentation of ALANA women in STEM. Historically, ALANA women, like women overall, have been substantially underrepresented in science and engineering relative to their representation in the overall population. According to most recent data, ALANA women earn less than 10% of bachelor's degrees in STEM fields (NSF, 2013). Educational attainment in STEM among ALANA women lags behind that of their White female and minority male peers (Ong et al., 2011). There is substantially less research on ALANA students (and, more specifically, ALANA women) in STEM compared to women; this is likely because ALANA students and ALANA women are so dramatically underrepresented in STEM, which limits researchers' ability to draw reasonable conclusions about this population.

This underrepresentation also illuminates the differences between what is deemed normal and abnormal; ALANA women doubly violate the social norms regarding who (e.g., which racial/ethnic groups) can do STEM as well as the norms of femininity (Ong, 2002). It is socially acceptable and rather common for a White male to have a job in STEM. It is somewhat unique for a woman to hold a similar job, as it is often considered masculine to do so. It is also unique for a person of color to hold a job in STEM, as it violates the White norms of the U.S. It is particularly rare for a woman of color to hold the same job, as she violates norms of both femininity and who is typically in STEM.

A rigorous search revealed only one major review on ALANA women in STEM fields (see Ong et al., 2011). These authors suggest that the lack of ALANA women in STEM fields is not due to lack of interest, but rather to a complex, layered set of factors influencing retention and achievement at the undergraduate level, as explained below.

Risk factors for ALANA women often parallel those for women and for ALANA students in STEM fields. For instance, ALANA women rarely encounter supportive faculty role models; more often they are met with condescending professors with low expectations for their achievement (Malcom et al., 1976). The same could be said for White women and ALANA students in STEM fields. ALANA women, however, encounter even fewer role models in their undergraduate, graduate, and professional work.

Moreover, the pre-collegiate experience, including family relationships, academic preparation, or high school counseling, can have a significant impact on the STEM pathway of ALANA women. Lack of academic rigor in secondary school can make undergraduate-level work difficult, and ALANA women, due to their particularly marginalized status, are more likely to encounter this problem than are other underrepresented groups (Malcom et al., 1976).

During college, institutional demographics and culture may have a profound impact on the experiences of ALANA women. African American female science graduates in a predominantly White institution reported that they operated in a "different world" from other-race students (Justin-Johnson, 2004). That is, these women experienced boundaries and expectations based on their gender and racial identities in their field of study. Social and intellectual exclusion from STEM may certainly discourage persistence among ALANA women.

Some social identities may confer additional risk of switching or dropping out for ALANA women in STEM fields. For instance, ALANA women who are also transfer students in STEM believe they are treated as if they do not belong in STEM fields due to their age, ethnicity, gender, and peer and instructor preconceptions that transfer students are not well-prepared (Reyes, 2011).

Cultural incongruity among underrepresented students in STEM. The factors described above contribute to the underrepresentation of White women and ALANA students in STEM at the societal and institutional levels. There are other factors, however, that influence STEM persistence within the classroom setting itself. Recall that the construct of cultural incongruity refers to the cultural identities and experiences of a particular group compared to the dominant group in a given institutional context (in this case, the STEM classroom). Cultural incongruity at the classroom level affects persistence for students from underrepresented groups.

Cultural incongruity among women in STEM. STEM classroom practices may not be congruent with the cultural preferences of women, and this incongruity may explain some differences in female persistence when compared to their male peers. For instance, a pervasive topic in persistence research is the "chilly climate" that may exist for girls and women in science classes. Chilly climate is described as a classroom environment that conveys the message that women are less capable and less serious compared to men in STEM fields (Hall & Sandler, 1982). This may leave women students feeling less confident than their male classmates and less likely to persist in STEM fields. Many women specifically cite feelings of psychological alienation or depression as reasons for leaving STEM fields, which may be due in part to this "chilly climate" (Seymour & Hewitt, 1997). These negative feelings may be caused by negative interactions with faculty and fellow students. In fact, negative interactions with faculty, including subtle or inadvertent sexist comments or attitudes, discourage women from participating actively in classroom and advising settings (Hall & Sandler, 1982; Seymour

& Hewitt, 1997). Women report that this chilly climate is prompted by unfair treatment from their male peers in STEM courses and departments (Cabrera et al., 2001).

The current underrepresentation of women in STEM classrooms has a reciprocal impact on women choosing to pursue or persist in STEM fields. Previous persistence research suggests that women feel more comfortable in science and math classes when they are not dramatically outnumbered by men (Seymour & Hewitt, 1997). There is also a dearth of female scientists and engineers as role models (Blickenstaff, 2005). Thus, the absence of female role models as professors, advisors, graduate students, and undergraduate students may, in itself, contribute to lack of academic success and persistence in STEM fields among women (Drury, Siy, & Cheryan, 2011).

Researchers also posit that STEM curricula and instructional approaches are not well-matched to the learning styles and preferences of many female students (Blickenstaff, 2005). This mismatch can be viewed as one aspect of cultural incongruity. Women tend to prefer to cover less material in greater depth (Blickenstaff, 2005) and prefer learning environments in which new material is contextualized within real-world situations (Knight, Mappen, & Knight, 2011). Female STEM students prefer small, interactive classes with many hands-on demonstrations and group activities (Persaud, Salter, Yoder, & Freeman, 2006). Unfortunately, many women characterize STEM courses as large, lecture-based, and impersonal (Seymour & Hewitt, 1997). This mismatch might account for the high dropout rate among women in STEM.

Overall, the pedagogy of science classes is thought to favor male students. Science teachers tend to reinforce girls' negative attitudes about science by devaluing the contributions of female students and overemphasizing rote learning (Blickenstaff, 2005).

These implicit biases against women in the STEM classroom may certainly have an impact on women's decisions not to enter and persist in STEM.

An inherent masculine worldview exists in scientific epistemology (Blickenstaff, 2005). For years, scientific research was used to support the notion that women had inferior mental capacity to men. Theories of feminist science are often left out of curricula because they pose a threat to traditional "objective" science as proposed by prominent male scientists (Blickenstaff, 2005). Apparently, the existence of women in science threatens the discipline itself.

Cultural incongruity among ALANA students in STEM. Recent research suggests that, similar to the effects on women, cultural incongruity may reduce the likelihood of persistence for Latin@ students in STEM (Cole & Espinoza, 2008). Latin@ and Chican@ students often struggle with a "culture clash" when they enter institutions of higher education (Fiske, 1988). The clash of a student's cultural beliefs and the dominant cultures of STEM may reduce the likelihood of graduation from a STEM major. For example, many Puerto Rican students cite racial discrimination and language problems as barriers to both education and employment in STEM fields (Malcom et al., 1976).

ALANA students face two specific challenges in relation to racial/ethnic identities, interracial stress and racism/discrimination. Interracial stress includes negative interactions between racial/ethnic minority students and the dominant culture, whereas racism and discrimination involve being mistreated, misunderstood, or disrespected as a direct result of one's racial/ethnic group (Jones, Castellanos, & Cole, 2002). Both challenges play out in at least some STEM classrooms. For example, results from a study of undergraduate engineering classrooms show that ALANA students felt unfairly treated by their White classmates (Cabrera et al., 2001). This unfair treatment seems to stem from both a culture clash as well as disrespect from White students and instructors.

ALANA students also perceive that faculty treat them differently compared to their White peers (Cabrera et al., 2001). ALANA students often describe STEM faculty as being unfair or discriminatory in regard to grading practices and offering additional help (Seymour & Hewitt, 1997). Research demonstrates, however, that having ALANA faculty in STEM fields contributes to an institutional context that supports students' development as scientists. For example, Black students at historically Black colleges and universities (HBCUs) report having a high level of support and frequent interactions with faculty (Hurtado et al., 2011). Moreover, Black students are more likely to persist if they have taken a STEM course taught by a black instructor (Price, 2010). Unfortunately, there is a lack of ALANA faculty in STEM at most major research universities (NSF, 2013), and racial/ethnic match with instructors is not a common reality for most ALANA students in STEM majors.

Course content may also contribute to cultural incongruence. The curriculum of many STEM courses often validates the majority culture, whereas the same validation is not extended to ALANA students (Fiske, 1988). For example, the key scientists and mathematicians presented in introductory courses are likely to be White. The cultural aspects of most story problems, including names, activities, etc., are also likely to be linked to majority White culture.

Many ALANA students also dislike the competitive STEM classroom culture. ALANA students feel that confidence in their abilities is challenged in the traditional

STEM climates of intimidation (Palmer et al., 2011). Collectively, these findings point to potential incongruity between the culture of STEM programs and the values and preferences of ALANA students.

A specific type of intimidation, termed racial micro-aggression, may directly impact persistence among ALANA students in STEM. ALANA students report the occurrence of faculty behaviors that communicate discomfort and/or differential or lower expectations, including ignoring, interrupting, maintaining physical distance, avoiding eye contact, offering little guidance and criticism, or attributing success to luck or factors other than ability (Hall & Sandler, 1982). Cultural differences in verbal and nonverbal cues may lead faculty and ALANA students to misread one another's attitudes and expectations (Hall & Sandler, 1982). These micro-aggressions might not be conscious forms of discrimination, but, nevertheless, they affect STEM outcomes for ALANA students.

Psychological exclusion is another aspect of cultural incongruity that affects many ALANA students in college, particularly in STEM majors. ALANA students report feeling isolated from other students in STEM courses (Bayer Corporation, 2012). Negative attitudes and beliefs toward ALANA students in STEM erode self-esteem and confidence (Seymour & Hewitt, 1997). Feelings of isolation in a White-dominant STEM world can have also have a negative impact on persistence and achievement for ALANA students (Seymour & Hewitt). This isolation could certainly lead to switching out of STEM.

Cultural incongruity among ALANA women in STEM. ALANA women are a smaller, more unique group compared to either women or ALANA students. In classroom interactions, ALANA women often face the effects of double stereotypes based on both race and sex (Hall & Sandler, 1982). For example, exclusion from informal study groups, which are typically all-male and/or all-majority, can restrict the pursuit of academic excellence for some ALANA women (Malcom et al., 1976). The overall climate in STEM learning environments has been cited as a key factor affecting persistence among ALANA women in STEM (Ong et al., 2011).

There are significant differences among women from different racial/ethnic groups based on their overall sense of belonging and perceptions of the campus racial climate (A. C. Johnson, 2007). Thus far, research has primarily focused on Hispanic/Latina (both Mexican American and Puerto Rican) and African American women in STEM. There remains a dearth of information about Native American and South East Asian women in STEM fields.

Mexican American female scientists often internalize cultural gender role expectations, and these strongly influence self-concepts and behavior. For example, women in Mexican-American families are taught to give priority to family needs and concerns, assume responsibility for most domestic tasks, and respect the authority of the man as head of the household and spokesperson for the family (Malcom et al., 1976). These expectations, both cultural and gendered, may be incongruent with the STEM classroom culture and, in turn, contribute to the underrepresentation of Mexican American women in STEM.

Among African American female scientists, many successful individuals attended predominantly Black educational institutions and, thus, participated in predominantly Black classrooms (Malcom et al., 1976). It is clear that the racial makeup of the learning environment was influential for these women. A predominantly White male classroom might be culturally incongruent for ALANA women, particularly African American women who have previously occupied predominantly African American spaces. The discomfort associated with this incongruence may influence persistence decisions.

As a group, ALANA women find three features of science classes particularly discouraging: (a) large size of the lecture classes; (b) the conventional pedagogical approach of asking and answering questions in class; and (c) emphasis on engaging in undergraduate research (A. C. Johnson, 2007). These “discouraging practices” can be sources of cultural incongruity for ALANA women. The pervasiveness of these practices throughout STEM fields might discourage ALANA women from choosing and persisting in these courses.

ALANA women face both “under-attention” and “over-attention” in the classroom. That is, ALANA women may be ignored completely or singled out as token representatives of their particular group (Hall & Sandler, 1982). Both phenomena are problematic and may impact persistence decisions.

Cultural values, such as the narrow focus on decontextualized science and the construction of science as a gender-, race-, and ethnicity-neutral meritocracy, have a negative impact on female scientists of color (A. C. Johnson, 2007). Viewing the science classroom as a neutral space, however, invalidates important features of students’ social identities. Thus, it might be culturally incongruent for a woman of color to view herself as simply a student in a STEM classroom when she has learned to identify as a Black female scientist or Latina engineer.

Effect of cultural incongruity on persistence in STEM. The foregoing review suggests that cultural incongruity in the classroom Isa reality for many White women and ALANA students in STEM majors. Class size, curriculum, instruction style, and other features of STEM classrooms are given meaning by students and instructors alike. These meanings are grouped together as a classroom culture, and this culture seems to be incongruent with the preferences of underrepresented students. The effect of this incongruity is key in understanding the experience and likelihood of persistence among underrepresented students in STEM.

Cultural incongruity may lead to negative student outcomes for underrepresented students in STEM fields. In their seminal study, Seymour and Hewitt (1997) concluded that, "the educational experience and the culture of the discipline (as reflected in the attitudes and practices of [STEM] faculty) make a much greater contribution to [STEM] attrition than the individual inadequacies of students or the appeal of other majors" (p. 392). Thus, it seems that the STEM culture affects students both in and out of the classroom. In light of the conclusions of Seymour and Hewitt, the widely accepted notion of a culture of STEM needs to be clearly defined and its effects on all students, particularly those from underrepresented groups, more thoroughly examined.

Underrepresented students who experience high levels of cultural incongruity may be more likely to switch out of STEM fields. Student responses on the *Cultural Congruity Scale* (CCS) significantly predict academic persistence decisions (Gloria & Kurpius, 1996). That is, when students believe their individual cultural identities are more congruent with their educational environment, they are more likely to persist in that academic environment.

Research to date provides some understanding of the effects of STEM classroom culture on persistence. Although there is some connection between classroom culture and persistence outcomes for underrepresented students, researchers have yet to unpack the mechanisms through which classroom culture impacts students' decisions to persist in or switch away from STEM majors.

Encouraging persistence among underrepresented students in STEM. A number of researchers recommend improving STEM culture – both at the institutional or system level and within the classroom – to help more White women and ALANA students persist and succeed in STEM. Specifically, efforts to reduce the gender gap in STEM should focus on encouraging the development of self-confidence among young women, challenging the persistent image of science as a masculine domain, and encouraging all students to recognize the connections between science and society. In addition, networks, faculty associations, financial assistance, and university support programs have been reported by women in STEM as creating a personalized educational experience that promotes both retention and graduation (Hyde & Gess-Newsome, 2000). More inclusive pedagogies may also help women succeed and persist in STEM fields (Sosnowski, 2002), thus lending support for the use of civic engagement pedagogies and other similar models in STEM classrooms (Knight et al., 2011).

In comparison to the disparities in physical sciences and engineering, the apparent success in achieving more equitable gender and racial/ethnic distribution of majors in the biological sciences warrants greater attention (Riegle-Crumb & King, 2011). Sax and colleagues (2010) suggest that the societal relevance of biological and pre-medicine majors has helped to reverse the gender gap in the biological sciences. Perhaps if the curriculum and pedagogy of other STEM areas similarly emphasized the many ways in which scientific work benefits the human condition, this could reduce the gender disparity in all STEM fields.

Unfortunately, such changes in classroom culture are often less effective for ALANA students than they are for women (Bayer Corporation, 2012). Generic "minority programs" do not address the needs of individual racial and ethnic groups (Seymour & Hewitt, 1997). If there is a misunderstanding and mismatch between the cultures of underrepresented groups and the STEM classroom culture, it needs to be more fully understood for specific groups. ALANA students, for example, require proactive student support services and creative experiences to persist and succeed in STEM majors (Palmer et al., 2011). Multicultural and bilingual education provides essential support for ALANA students (Malcom et al., 1976). Inclusive pedagogies, which acknowledge cultural and learning differences, can reduce the intimidating culture of many STEM classrooms (Palmer et al., 2011). STEM faculty should be rewarded for effective teaching as well as excellence in research so that research universities can create cultures of success in STEM fields (Anderson et al., 2011). These and other changes may improve outcomes for ALANA students in STEM fields.

Research has identified a number of protective factors that can support retention, persistence, and/or achievement for ALANA students in STEM (see Hurtado et al., 2011; Hyde & Gess-Newsome, 1999). For instance, peer support, participation in STEM-related activities, and previous preparation promote retention, persistence, and success among college ALANA students pursuing degrees in STEM fields (Palmer et al., 2011). ALANA women can also develop protective factors that help them cope with the double bind of two oppressed identities. Research recommends that ALANA women formulate multiple identities (academic, social, and intellectual) to help them persist in STEM majors (Tate & Linn, 2005). In one study, researchers found that ALANA women used their bodies (through dress, hair, speech, weight, etc.) to gain acceptance in the field of physics (Ong, 2002). That is, these women learned to maneuver their physical selves to be congruent with or different from the expectations placed upon them in STEM learning environments.

Despite the fact that individuals can develop protective factors to increase persistence, there is much more that can be achieved at the classroom and institutional level Suggestions include (a) cultivate a culture of respect (e.g., use cooperative groups, avoid dividing students by gender or racial/ethnic identities for class activities or seating arrangements, eliminate sexist and/or racist language/imagery from printed materials, do not tolerate sexist and/or racist language or behavior in the classroom); (b) reduce reliance on stereotypes by making performance standards and expectations clear (e.g., develop clear and consistent grading practices for all students, celebrate and encourage students' academic strengths); and (c) urge underrepresented students to enroll, persist, and succeed in STEM courses (e.g., create examples and assignments that emphasize the way that STEM can improve the quality of life of living things, increase depth and reduce breadth of content in introductory courses, openly acknowledge the political nature of scientific inquiry, ensure that students have equal access to the teacher and classroom resources; Blickenstaff, 2005; Hill, Corbett, & St. Rose, 2010). These changes may help to promote cultural congruity for all students in STEM fields.

Experts suggest that STEM program administrators should support accountability-based plans of action and comprehensive assessment to build confidence in all students, particularly ALANA students in STEM majors (Palmer et al., 2011). Improving the persistence of underrepresented students in STEM requires a change in institutional mission and values. To reflect these values, group study, tutorial centers, faculty feedback, and improving student orientation are recommended (Hrabowski III & Maton, 2009). Institutional, department, and classroom changes can help promote change in attitudes and support for underrepresented students in STEM.

Conclusion

Research demonstrates that White women and ALANA students continue to be underrepresented in STEM fields for a number of reasons that are connected to the culture of the STEM discipline and learning environments. There is ample research about women and a moderate amount of research about ALANA students to provide evidence of underrepresentation in STEM fields and to formulate possible reasons for this disproportionality. Although some of this literature describes aspects of the institutional and classroom culture that may affect students' decisions to persist versus drop out of STEM fields, there remains a gap in our understanding of dimensions of classroom culture that are associated with cultural incongruities for underrepresented groups and how these cultural incongruities undermine persistence in STEM majors for underrepresented groups.

A significant number of STEM department chairs report an increase in enrollment for White women and ALANA students in STEM introductory courses; however, most indicate that ALANA students remain underrepresented in terms of course enrollment and degree completion—both indicators of persistence (Bayer Corporation, 2012). The representation of women in STEM has improved in the last 20 years, but there is still a long way to go before women are equally represented (Blickenstaff, 2005). Most STEM department chairs agree that increasing the number of White women and ALANA students in STEM education and STEM careers remains an important national need (Bayer Corporation).

Despite evidence of underrepresentation of White women and ALANA students in STEM, as well as research identifying reasons for underrepresentation, there remains a dearth of research that addresses the construct of cultural incongruity in STEM classrooms as contributing to persistence. Questions remain regarding the effects of classroom cultural incongruity on student thinking about persistence and switching decisions. Specifically, *how does classroom culture, including cultural congruity and incongruity, influence students' thoughts about persistence and switching decisions, particularly among underrepresented students in STEM?*

Cultural incongruity exists in multiple contexts, and may be particularly salient for underrepresented students in STEM classrooms. Cultural incongruity can manifest itself in instructional practices, pedagogies, curricula, and other aspects of classroom culture. Despite this current understanding of classroom culture, researchers have yet to draw upon students' and instructors' lived experience in the STEM classroom to describe this incongruity and the ways in which such experience influences student thinking about persistence and switching decisions. This study will address the gap in the literature.

Chapter 2: Statement of Problem

Purpose

This study was designed to explore the classroom culture of introductory STEM courses, delineate factors that contribute to this culture, and examine possible consequences of classroom culture, cultural congruity, and cultural incongruity on students' thinking about persistence and switching decisions. Because each classroom has a unique culture that affects student learning outcomes (Zastavker et al., 2013), it is important to consider this classroom culture—and, more specifically, the cultural congruity or incongruity experienced by students in the classroom—when exploring reasons for student dropout and switching away from STEM.

The current study focused on the (non)congruence between students' culture and the classroom culture as a key factor that influences thinking and decisions related to persistence and switching, specifically among underrepresented students in STEM (i.e., White women and ALANA students). The study sought to identify the groups for which cultural incongruity exists and to characterize classroom practices through which incongruity may be manifested. Data addressed questions about the characterization of classroom culture, as well as influences on and consequences of this culture, particularly as they relate to student persistence in STEM majors.

Theoretical Framework

The theoretical framework for this study derives from field theory. Field theory was originally used to study individual perception and motivation (Lewin & Cartwright, 1964). More recently, educational researchers have relied on the work of Pierre Bourdieu in conceptualizing their studies within field theory. For Bourdieu, a field consists of a structured space of positions (e.g., hierarchies) and a space of position-takings (e.g., meanings) (Bourdieu, 1993). Field theory explains the regularities and organization of individual action framed relationally vis-à-vis other actors and social relations (Martin, 2003). In these metaphorical fields, actors are oriented toward each other and toward shared (and sometimes conflicting) goals. Thus, to understand action in any particular setting, one must have a relational understanding of how actors' social positions influence a range of perceptions, meanings, and strategies that are experienced with varying levels of intensity and direction.

In this study, the classroom is conceptualized as a field situated within the larger fields of the campus and even broader institutions (e.g., system of higher education, nation, globe). In viewing the classroom as a field, the actors are students and instructors. These actors are oriented toward each other and the course content in diverse ways; this process creates classroom climate. Actors often share goals surrounding teaching and learning in the classroom; however, sometimes these goals are in conflict (e.g., to foster competition vs. to foster collaboration). Actors' perceptions and interpretations of the student-instructor relationships and student-student relationships also influence the classroom climate. Finally, social, institutional, and situational positioning alters the social relationships and interactions within the field (or classroom). Both students and instructors share the space, but attach unique and individual meaning to the classroom climate. This meaning is termed classroom culture. Classroom culture affects the classroom as a field and helps actors make meaning of the relationships, goals, and actions that take place within it (see Figure 1).

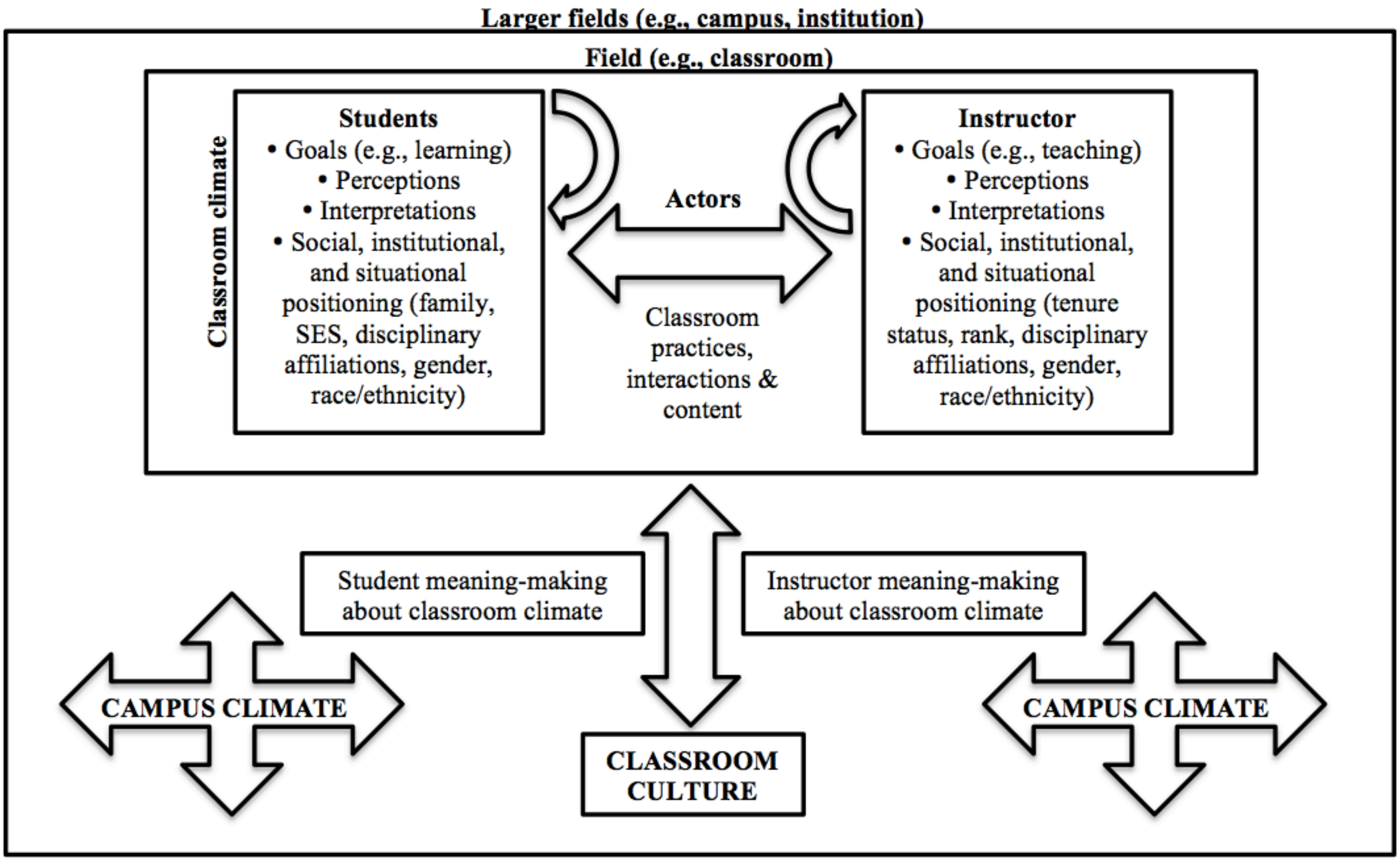

Figure 1. Field-theoretic model of classroom culture.

Research Questions and Predictions

The following questions were addressed in the study. Although the questions are primarily descriptive in nature, cursory predictions were formulated based on what is known from extant research.

Research Question 1. How do students and instructors describe the classroom culture of undergraduate introductory STEM courses?

Prediction 1. In popular media and at many institutions of higher education, STEM classrooms, overall, are characterized as having a "weed-out" (i.e., competitive) culture. This type of culture is viewed as being particularly characteristic of introductory STEM courses; in fact, students regularly refer to them as "weed-out courses." Thus, although the author expected the culture of introductory STEM courses to be characterized on the basis of multiple dimensions, the author specifically predicted that both students and instructors would include this notion of weed-out culture in their descriptions of STEM courses.

Research Question 2. What factors do students and instructors describe as contributing to the classroom culture of introductory STEM courses?

Prediction 2. Classroom culture is developed through interactions between students and instructors in a classroom, as well as through the diverse and individual meanings ascribed to these interactions. Thus, the author predicted that perceived classroom culture of introductory STEM courses will be influences by multiple factors, including large class sizes (100+ students), lecture-based instruction, heavy workload, need for independent learning outside of class, limited instructor contact, and occurrence of micro-aggressions that might be disrespectful toward women and/or ALANA students.

Research Question 3. How do students and instructors of introductory STEM courses describe the influence of classroom culture, including cultural congruity or incongruity, on students' thinking about decisions related to persistence in and switching away from STEM majors?

Prediction 3. The author expected students and instructors alike to report that negative classroom culture, including a "weed-out" climate, influences students to think about switching away from STEM majors. The author also predicted that underrepresented students (i.e., White women and ALANA students) would describe the experience of classroom culture differently than will White male students, specifically that underrepresented students would describe more cultural incongruity. That is, the author expected that underrepresented students would be more likely to report that social factors (e.g., race and gender) contribute to a negative (and incongruent) classroom culture, which influences them to think about switching away from STEM.

Chapter 3: Method

Context for Current Study, Talking about Leaving – Revisited

The data for this study were drawn from a larger, five-year (2012-2017) mixed-methods research project co-funded by the National Science Foundation (NSF) and Alfred P. Sloan Foundation. The project's principal investigators are Anne-Barrie Hunter (University of Colorado–Boulder) and Mark Connolly (University of Wisconsin–Madison). The research builds on previous findings from Seymour and Hewitt's 1997 book entitled *Talking about Leaving: Why Undergraduates Leave the Sciences* (*TAL-1*). The current project, known as *Talking about Leaving – Revisited* (*TAL-R*), re-examines why undergraduates switch away from – or persist in – STEM majors.

TAL-1 (Seymour & Hewitt, 1997) included data from seven U.S. institutions of higher education and found that attrition from intended majors, overall, was about 40% in engineering, 50% in the physical and biological sciences, and 60% in mathematics. Educational experiences were reported as the primary reasons students switched out of these fields, while these same experiences were reported by non-switchers as the most significant obstacles they had to overcome in order to attain their degree. *TAL-1* also found that White women and ALANA students were disproportionately represented among students leaving STEM majors. Importantly, ALANA students reported a lack of high school preparation in STEM content areas. Despite efforts to increase persistence in STEM, the percentage of undergraduates leaving STEM majors remains largely the same 20 years later (NSF, 2013).

TAL-R has returned to six of the original seven institutions to explore what has changed or not changed over the past two decades in the learning experiences of undergraduates in STEM majors, and whether these changes affect persistence, particularly among White women and ALANA students. *TAL-R* includes four component studies: (a) National and Institutional Study; (b) Persistence Study; (c) Institutional Change Study; and (d) Gateway Course-Taking Study. To provide a context for the proposed research, each *TAL-R* component study is briefly described in the following paragraphs. The current research is specifically associated with the Gateway Course-Taking Study component.

National and Institutional Study. The National and Institutional Study focuses on national and institutional patterns of switching away from or into STEM majors, particularly during the years since the *TAL-1* study. This component study also compares switching patterns in STEM majors to switching patterns in non-STEM majors to determine if patterns in STEM switching are unique. Patterns associated with students' race/ethnicity, gender, and socioeconomic status (SES) are examined in relation to course-taking and academic performance. Data include transcripts and student attribute data (e.g., race/ethnicity, gender) from participating institutions, as well as nationally representative data sets to provide a national portrait of switching patterns. The aim is to compare these patterns to the original findings of *TAL*-1 to determine what (if any) changes in STEM-field switching have occurred among undergraduate students.

Persistence Study. The Persistence Study is designed to replicate and extend the design of the *TAL-1* study. Researchers working on this component study aim to learn whether undergraduates switching away from STEM majors are leaving for the same reasons found in *TAL-1*, and whether any factors contributing to the lack of persistence in STEM have been ameliorated. Researchers seek to uncover variations in interview responses based on students' race/ethnicity, gender, past academic achievement, and chosen major/discipline. The Persistence Study data consist of transcripts from in-depth, semi-structured interviews with switching juniors and non-switching seniors in STEM fields. The goal of these interviews is to gain a rich understanding of student experiences and determine the patterns and causes of persistence and attrition in these fields.

Institutional Change Study. The purpose of the Institutional Change Study is to provide a contextual backdrop for *TAL-R's* analysis of patterns of persistence. This component study is designed to examine efforts to improve undergraduate STEM education, both nationally and at the six *TAL-R* institutions, since the time of the *TAL-1* study. Researchers aim to discern what institutional change efforts have been made to improve undergraduate STEM education, particularly in the areas of undergraduate instruction, assessment, and curricula. Researchers are also examining the extent to which institutional change efforts have influenced, both positively and negatively, efforts to improve undergraduate instruction, assessment, and curricula in STEM courses.

Gateway Course-Taking Study. The Gateway Course-Taking Study (GCTS) is the component study from which the data for the current study have been drawn. The GCTS is centered on instructors and students in gateway, or introductory, courses for undergraduate STEM majors (e.g., Calculus 1, Introduction to Programming, Differential Equations for Scientists and Engineers, General Chemistry, etc.). Many of these introductory courses tend to discourage students from continuing in STEM fields (Seymour & Hewitt, 1997). In fact, some researchers refer to these as "barrier" courses that effectively prevent some students from achieving success in STEM (Suresh, 2006).

GCTS researchers aim to explore instructional practices for introductory STEM courses and the relationship between these practices and student persistence.

Data sources for the larger GCTS include (a) individual faculty interview transcripts, (b) student focus-group interview transcripts, (c) classroom observations using the *Teaching Dimensions Observation Protocol* (TDOP; Hora & Ferrare, 2013), and (d) student surveys using an augmented version of the *Student Assessment of* their *Learning Gain*s (SALG; (Seymour, Wiese, Hunter, & Daffinrud, 2000).

The author of the present study was previously employed as a Project Assistant on the GCTS team. Duties included interview protocol development, course sampling, correspondence with student participants, focus-group interview scheduling, data entry, coding, and analysis. Currently, the author is employed as a Research Assistant for the TAL-R project, and is responsible for the development of research projects and scholarly works to disseminate study results, including but not limited to the development and dissemination of this dissertation study.

Data Sources

Two data sources from the GCTS were used for the current study: (a) individual faculty interview transcripts, and (b) student focus-group interview transcripts. The following sections describe the participants, interview procedures, and analytical procedures.

Participants

Participants included the instructors and students from two large, research-based institutions who participated in interviews for the GCTS. The sample included 24 instructors who participated in individual interviews and 115 students who participated in 20 focus-group interviews. See Table 1 for the number of participants by institution.

Table 1

Participants by Institution

	Institution		
	A	B	Total
Number of Instructor Participants	10	14	24
Number of Student Participants	54	61	115
Number of Student Focus-Groups	9	11	20

Institution recruitment and sampling. Institutions participating in *TAL-R* were selected to replicate the original *TAL-1* study (Seymour & Hewitt, 1997), with the original findings providing a baseline from which to investigate changes in STEM learning experiences and persistence patterns. The two institutions selected for this study included an urban Midwestern university and a mid-Atlantic flagship university. Both institutions are large, public institutions that are typical of the type of institutions that confer the largest percentage of STEM degrees in the U.S. higher education system (American Institutes for Research, 2013). These types of institutions also tend to have lower rates of persistence and undergraduate completion rates in STEM fields when compared to small or mid-sized private institutions (Rine & Song, 2014). Public research universities are presently lacking the productivity and efficiency in training undergraduates in STEM for both later graduate education and future careers, thus justifying a selective focus on these two institutions.

Introductory STEM course sampling. To obtain the data used for the GCTS as well as the present study, *TAL-R* researchers (including the author) searched institution course enrollment websites to construct a list of introductory STEM courses from which instructors and students might be selected. After constructing the preliminary course list, the document was submitted to the project's contacts at each participating university, typically faculty members in a STEM field, who determined whether the courses fit into the introductory description (see p. 13) and offered suggestions for additional courses to be included. Courses were sampled if they (a) fit the introductory description, and (b) were being offered during the time of the institution's site visit. All of the selected courses are required courses for students in STEM majors.

Faculty member recruitment and sampling. Faculty member participants included a total of 24 instructors of record for selected introductory STEM courses at the two institutions. *TAL-R* researchers (not including the author) contacted the instructors via email approximately two months prior to the site visit at each institution. Researchers scheduled individual interviews with instructors who volunteered to participate. At the time of the individual interview, instructor participants read, initialed, and signed informed consent documents (see Appendix A). Instructors self-reported gender, racial/ethnic identity, field of study, and job title (see Table 2).

Table 2

Instructor Participant Characteristics

Characteristic	n	% of total sample
Gender		
Male	19	79%
Female	5	21%
Racial-Ethnic Identity		
White	16	67%
Asian or Pacific Islander	2	8%
Latin@ or Hispanic	1	4%
Black or African American	0	0%
American Indian or Alaska Native	1	<1%
Not reported	4	17%
Field of Study		
Chemistry	6	25%
Physics	5	21%
Engineering	4	17%
Biology	3	13%
Computer Science	3	13%
Mathematics	3	13%
Job Title		
Associate Professor	7	29%
Lecturer or Instructor	6	25%
Professor	5	21%
Assistant Professor	2	8%
Teaching Assistant	1	4%
Other	3	13%

Student participant recruitment and sampling. Student participants included 115 undergraduate students enrolled in selected introductory STEM courses from the two institutions. Faculty participants contacted enrolled students via email approximately one month prior to the site visit at each institution. Students were offered $20 for their participation in the focus-group interviews. Interested students completed a brief survey indicating availability for a focus-group interview. The author contacted student volunteers to schedule focus-group interviews. Instructors did not know which students volunteered for or participated in focus-group interviews. At the time of the focus-group interview, student participants read, initialed, and signed informed consent documents (see Appendix B). Students self-reported gender, racial/ethnic identity, and major (see Table 3). During the interviews, most students reported being either a freshman or sophomore; however, year of study data are not available for all student participants.

Table 3

Student Participant Characteristics

Characteristic	n	% of total sample
Gender		
Male	57	50%
Female	58	50%
Racial/ethnic Identity[a]		
White	76	66%
Asian or Pacific Islander	23	20%
Black or African American	6	5%
Latin@ or Hispanic	5	4%
American Indian or Alaska Native	0	0%
Multi-racial	2	2%
Not reported	7	6%
Major[b]		
Biology	92	37%
Engineering	71	29%
Other Science	43	17%
Computer Science	32	13%
Other Non-Science	14	6%
Mathematics	8	3%
Social Science	6	2%
Undeclared	1	1%

[a]Students who reported multiple racial/ethnic groups are counted as members of all the groups indicated as well as multi-racial.
[b]Students who reported multiple majors are counted as a student in all of the majors indicated.

In keeping with the field theory framework, it is important to note that the focus-group interview constitutes a "field" where the actors (i.e., students, interviewer) interacted. Student focus-group interviews were held in available classrooms on campus. The interviewers were researchers from the *TAL-R* team (3 White men, 1 White woman). The students within each group were classmates who shared the same instructor for at least one of their academic courses. See Table 4 for the composition of each focus-group by race/ethnicity and gender.

Table 4

Student Focus-Group Composition by Race/Ethnicity and Gender

Gender & Race/Ethnicity	Focus-Group #																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
# of White women	2	5	2	6	2	1	4	1	0	1	2	0	2	2	3	0	2	2	1	0	38
# of White men	0	2	4	0	0	4	1	5	0	0	4	2	4	1	2	0	3	0	2	2	36
# of Asian women	1	0	0	1	2	1	0	0	1	2	0	1	1	0	0	0	1	0	0	1	12
# of Asian men	0	0	0	0	0	2	0	1	0	0	2	1	0	0	2	1	1	0	1	0	11
# of ALANA women	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	4
# of ALANA men	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0	0	2	1	7
# of women not reporting race	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	1	1	4
# of men not reporting race	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	3
Total	3	8	6	7	4	8	5	9	4	4	8	5	8	3	8	2	7	3	7	6	115

Procedures

Data for this study were derived from individual instructor interviews and student focus-group interviews. GCTS researchers interviewed instructors using a semi-structured interview protocol. See Appendix C for the interview protocol and Appendix D for an example of an interview transcript. Researchers also facilitated student focus-group interviews using a semi-structured interview protocol. See Appendix E for the focus-group interview protocol and Appendix F for an example of a focus-group interview transcript.

Faculty member individual interviews. Each faculty member interview followed a semi-structured protocol developed by the GCTS team. During the development of the protocol, team members focused on aligning the interview questions with the GCTS's overarching research aims. Team members also paid close attention to the wording and phrasing of the questions to ensure that faculty participants would understand questions. The interview questions were shared with experts in the field (i.e., *TAL-R* Advisory Board) to solicit feedback related to the framing and scope of the protocol. The interview protocol was designed to explore *TAL-R* questions about teaching and learning, student interaction and advising, influences on teaching practices, classroom culture, professional development, and student persistence (see Appendix C).

The GCTS team and primary investigator from the University of Colorado–Boulder facilitated three training workshops for interviewers. Four researchers, three from the University of Wisconsin–Madison (not including the author) and one from the University of Colorado–Boulder, were trained as interviewers. The author participated in training but did not collect any interview data for the GCTS team. During the training workshops, each interviewer read the interview questions and discussed the primary focus or intent of each question. After three training sessions, interviewers reached consensus on the principal intent of each question in both the individual and focus-group interview protocols. Interviewer consensus about each question's intent was necessary to be able to compare interview responses across courses and institutions.

Following training, one trained interviewer conducted a pilot interview with a faculty member at the University of Wisconsin–Madison. The author was present during the pilot interview. The pilot interview provided *in vivo* practice for the interviewer to use his skills in questioning and probing faculty members on major topics. The instructor interviewee provided feedback on the interview protocol questions and the interviewer's style, which was shared with other interviewers.

Student focus-group interviews. Each student focus-group interview followed a semi-structured protocol developed by the GCTS. Similar to the instructor interview, during the development of the focus-group interview protocol, team members focused on aligning the interview questions with the GCTS's overarching research questions and worked to ensure student participants would understand questions. Focus-group interview questions were shared with members of the *TAL-R* Advisory Board, who provided feedback related to the framing and scope of the protocol. The focus-group interview protocol was designed to explore *TAL-R* questions about teaching and learning, in-class experience of instructors, activities outside the classroom, student interaction and advising, classroom culture, and student persistence (see Appendix E). The same interviewers and training procedures as for instructor interviews were used for student focus-group interviewers.

The institutional review board (IRB) at the University of Colorado–Boulder approved the *TAL-R* project in December of 2012. At the University of Wisconsin–Madison, an IRB Authorization Agreement (IAA) dated November 26, 2012 gave responsibility for review and continuing oversight of the research project to the IRB at the University of Colorado-Boulder (see Appendix G).

Approximately two months prior to the site visit at each institution, the GCTS team began course sampling, faculty and student recruitment, and interview scheduling. Each site visit lasted two weeks, with members from the *TAL-R* research team collecting data throughout this period. The author was not present for the site visit at Institution A (October 2013). The author was present for the site visit at Institution B (November, 2013), but did not collect data or facilitate interviews.

During the site visit for each institution, one of the four trained researchers conducted the instructor interviews. Individual interviews were held in the instructor's office and lasted approximately one hour. Interviews were digitally recorded. In the months following each site visit, *TAL-R* staff (not including the author) transcribed the interviews and uploaded them to *NVivo 10* software (*NVivo*, 2012) for coding and analysis. *NVivo10* software was selected by the TAL-R project for its ability to add rigor and validity to the analysis of particularly large data sets (Welsh, 2002).

Also during the site visit, one of the four trained researchers interviewed students from 20 of the 24 courses (88%) taught by the instructors who were interviewed. Courses that lacked sufficient student volunteers did not have focus-group interviews. The average size of each focus-group was 5-6 students (range = 2 to 9 students) (see Table 4). Focus-group interviews were held on campus and lasted approximately 90 minutes. Students assumed pseudonyms (e.g., Hugo, Catherine) and were asked to identify who was speaking (e.g., "This is Hugo…") to aid in accurate transcription and student attribute coding. Focus-group interviews were digitally recorded, transcribed, and uploaded to *NVivo 10* software (*NVivo*, 2012) for coding and analysis.

Design

The study used a qualitative design incorporating grounded theory and constant comparison analysis (Charmaz, 2006; Glaser & Strauss, 1967). A qualitative design was chosen in order to replicate the *TAL-1* study (Seymour & Hewitt, 1997) and to provide detailed information about what has changed in the intervening years. Strategies of inquiry for this study (see pp. 44-46) also clearly point to qualitative research methods. Qualitative research methods allow for descriptive inquiry and textual analyses and are particularly useful for obtaining insights into problematic experiences and the meaning attached to these experiences for specific groups (Leech & Onwuegbuzie, 2007). In this way, both STEM classroom culture and its relationship to students' thinking about persistence and switching decisions may be richly described and thoroughly explored.

Development of codebooks. To develop the codebooks for this study, the author purposefully selected 16 transcripts (eight individual instructor interviews and eight student focus-group interviews) to include multiple institutions and course topics. Next, the author coded these transcripts using a multi-step procedure that included first-cycle and second-cycle coding methods (see Table 5). First-cycle coding methods (Saldaña, 2013) used in this study included holistic coding, attribute coding, initial coding, causation coding, and simultaneous coding (see ***First-cycle coding*** below). Between first-cycle and second-cycle coding methods, a "themeing" [sic] of the data took place

(Saldaña, p. 175). After developing a thorough understanding of the data and its patterns, second-cycle coding methods were used to reorganize and reanalyze data; these second-cycle methods include a combination of focused and axial coding (see ***Second-cycle coding*** below).

Table 5

Codebook Development

Coding Type	Description
First Cycle:	
Holistic coding	Organized transcript data by broad topic
Attribute coding	Organized transcript data by speaker
Initial coding	Coded researcher's initial thoughts for later analysis
Causation coding	Coded antecedents, descriptors, and consequences
Simultaneous coding	Coded two or more different codes to a single datum
Themeing of the Data	Grouped codes by theme
Second Cycle:	
Focused coding	Refined initial codes and causation codes
Axial coding	Organized codes into categories for analysis

First-cycle coding. GCTS team members (including the author) organized transcript data by broad topic via a holistic coding procedure (Dey, 1993). This procedure was used to segment transcript data according to the major topics covered in the individual and focus-group interviews. The goal of holistic coding is to focus on specific parts (segments) of the data, or "to 'chunk' the text into broad topic areas, as a first step to seeing what is there" (Bazeley, 2007, p. 67). Researchers relied on both interviewer transition statements and the content of the entire interview to determine when participants discussed ideas about classroom culture and persistence. After training and discussions, the three researchers who holistically coded interview transcripts underwent inter-rater reliability testing. For instructor interviews, agreement across researchers reached a Cohen's *kappa* coefficient greater than 0.98. For student focus-group interviews, the *kappa* value was greater than 0.70.

In accordance with the research aims of the current study, classroom culture and persistence segments were the key areas of analysis. Classroom culture included instructors' and students' thoughts, feelings, beliefs, and behaviors in a specific classroom teaching and learning environment. Specifically, interviewers asked instructors and students whether their classroom has a culture, what creates the culture, and whether the culture affects their behavior in relation to the course. Persistence, in this context, was defined as maintaining enrollment and continuing on the path to complete a degree in STEM. Interviewers asked about factors contributing to students' thinking about persistence (and the opposite, switching) decisions for students in STEM majors. The purpose of selecting segments on classroom culture and persistence was to draw connections and make clear the relationship between these two related constructs.

Following holistic coding, attribute coding was applied to transcripts to note participant characteristics such as gender, race/ethnicity, etc. (Saldaña, 2013). Data about student attributes were collected via survey prior to student participation in focus-group interviews, and these attributes were linked to student pseudonyms in the audio recordings. As a data management technique, attribute coding aids in organizing transcripts and segments of text according to the attributes of the individual who is speaking. These attributes provide important participant information for later phases of analysis and interpretation.

Next, initial coding (Glaser & Strauss, 1967) was used to further break down transcript segments into discrete parts. This open-ended style of coding is used as a starting point to provide "analytic leads for further exploration" (Saldaña, 2013, p. 101). The author coded transcripts with initial thoughts and uncovered relationships between topics discussed in the individual interviews and focus-group interviews. The following is an excerpt of a transcript to illustrate the process and outcome of initial coding:

[I: Do you guys think that – that Calc 3 is a weed-out course?]

JOSE: This is Jose speaking, um, [1]no, because, um- maybe for a Bachelor of Science degree here, I'm not sure about everywhere else, but, um, my roommate and uh another friend I have both took up to Calc 2 in order to get a BA in Biology with, um, one of 'em was pre-med, one of 'em was pre-dental. They stopped taking it because they don't need Calc 3 at all for that, and they didn't switch it up to a B.S., they didn't really care, they're just like "Eh whatever, it doesn't really matter." So, they didn't even take it, yet it's still- [2]like they still dropped this quarter because they didn't – like "Organic chemistry was too hard," y'know, it – it's just [3]we go to a business school, so everyone around us is y'know, going out on Thursdays and we have to – [4]have class on Friday, so it's like, it's a lot of like, tempting with like "Hey come have a social life!" y'know? And it's just like, we're not allowed to. And we're the only ones here. Y'know it's – [5]we don't have a good community for it, and like, it's just sorta like, I – [6]y'know you hang out with all these business majors and you're just kinda jealous, and they're kinda y'know like saying it like "Oh come on, switch over to business" jokin' around with you and you're- then you start seriously considering it. That's what happened to both of them. Which is, y'know, their choice. [7]But they didn't even have to take Calc 3 to do what I'm planning on doing, y'know, they coulda gotten into a medical school and been a doctor, done everything I would've done, but they didn't have to have Calc 3.

[1]Calc 3 is not a weed-out course because it is not required (weed-out courses must be required, not just dropped)

[2]Organic chemistry is a weed-out course because it causes students to drop a STEM major

[3]This institution is characterized as a "business school" (most students are business majors)

[4]STEM majors are not allowed to have a social life based on course schedule

[5]The community/culture of the institution is not good for STEM majors

[6]Friends influence switching behavior

[7]Calc 3 is not a weed-out course because it's not required

The author's initial interpretive codes were then compared for similarities and differences.

To determine causal processes described by students and instructors, the transcripts were coded using a causation coding procedure (Saldaña, 2013). Sets of three codes (antecedent, descriptor, and consequence codes) were arranged to form pathways to model causation networks leading to (or away from) student outcomes in STEM. This procedure helped to draw connections between elements of classroom culture and folk theories of student persistence. To illustrate this process using the above excerpt, the initial codes (noted above) were grouped together as antecedent codes, in that both friends and course scheduling seem to have influenced (i.e., functioned as antecedents for) this student's thoughts about switching away from STEM.

To be clear, these first-cycle coding methods were applied in an overlapping fashion, an approach called simultaneous coding (Saldaña, 2013). Simultaneous coding involves "the application of two or more different codes to a single qualitative datum, or the overlapped occurrence of two or more codes to sequential units of qualitative data" (Saldaña, p. 267). This allowed for multiple holistic, attribute, initial, and causation codes to overlap and guided both the development of codebooks and later data analysis.

Themeing of the data. After these first-cycle coding methods were completed, a "themeing of the data" occurred (Saldaña, 2013, p. 175) to determine major themes regarding classroom culture and students' thinking about persistence decisions. In this step, a "theme" was considered any construct that links expressions found in the text (Ryan & Bernard, 2003). Using the transcript excerpt above as an example, the "friends" antecedent code was themed and grouped with other social factors such as "family," "gender," and "race and ethnicity."

Second-cycle coding. Second-cycle coding included focused coding and axial coding (Saldaña, 2013). Focused coding involved searching for the most frequent or significant themes to develop "the most salient categories" (Charmaz, 2006, p. 46) in the data and required "decisions about which initial codes make the most analytic sense" (Charmaz, 2006, p. 57). In the current study, repeated and similar constructs were grouped together and organized into a hierarchical outline. This cycle was repeated several times to refine the major themes. After several readings of the transcripts, the social antecedent themes included the following: family, peers, gender, race and ethnicity, socioeconomic status and economy, and nationality and immigrant status.

After using the first draft codebooks to code 16 transcripts, axial coding (Charmaz, 2006) was used to organize themes according to broader categories. For example, initial categories for antecedent themes included student factors, instructor factors, institutional factors, and physical setting. Axial coding "relates categories to subcategories [and] specifies the properties and dimensions of a category" (Charmaz, 2006, p. 60). The axial coding process was used to add definition and clarity to categories, subcategories, and individual themes.

Throughout this process, the author consulted with other *TAL-R* researchers regarding the credibility of the themes and definitions. Using a "peer debriefing" process (Bloomberg & Volpe, 2015, p. 163), researchers examined assumptions and considered alternate ways of looking at the data before deciding on the final codebook (see Appendix H). Saldaña (2013, p. 24) suggests that "the final number of major themes or concepts should be held to a minimum to keep the analysis coherent." Thus, a few themes were eliminated for brevity and alignment with the structure of the data.

NVivo10 software (*NVivo*, 2012) was used to apply the holistic codes, attribute codes, and themes to all of the transcripts in the data set. Computer assisted qualitative data analysis software, such as *NVivo10*, aids researchers in presenting an accurate and transparent picture of the data (Welsh, 2002). Intra-rater reliability data were calculated for all of the transcripts that the author coded more than once. The average kappa value was 0.47, with 97.20% agreement. Upon the application of codes to the data set, the author began the process of analyzing results.

Chapter 4: Results and Discussion

Results

The themes arising from transcript data are the results described and discussed in this chapter. Initial thematic categories, titles, and definitions were revised and refined throughout the iterative coding process. Upon reviewing the full set of transcript data, the author determined that the themes discussed among students and instructors were sufficiently similar that the two lists were merged.

To address each of the three research questions in this study, themes are divided into three major categories: antecedents, descriptors, and consequences of classroom culture. Each of these broad categories is linked to a piece of the causal pathway in the development, description, and outcomes related to classroom culture in introductory STEM courses.

Frequency tables were developed using NVivo 10 (2012) software. Table 6 is an organization and delineation of key findings, and it presents frequencies for each of the themes. Table 7 presents frequencies for each of the themes organized by both gender and race/ethnicity of the speaker. It should be noted that frequencies were calculated for total number of mentions rather than total percentage of coverage; this method was used to avoid the overrepresentation of participants who spoke at length about a particular topic and ensures the representation of brief mentions of each topic or theme.

Table 6

Definitions and Frequency of Themes Across Students and Instructors

Category, ***Subcategory***, or *theme*[1]	Definition	Frequency: Students (n = 115)	Instructors (n = 24)	Total (n = 139)
Antecedents	**Any discussion of a variable that directly influences classroom culture or indirectly influences student outcomes**	**2378**	**1047**	**3425**
Student factors	Factors related to individual student thoughts, beliefs, opinions, and behaviors	808	352	1160
Future career options & earnings	*Students' concern with career options, job opportunities, graduate training, and/or income*	*160*	*40*	*200*
Grit & stubbornness	*Students' persistence with disregard for obstacles. Includes an unwillingness to switch or drop out for any reason*	*28*	*13*	*41*
Hard work	*Intrinsic motivation and/or individual persistence and effort. Includes the amount of hard work required to persist*	*87*	*47*	*134*
Intelligence & skill	*Students' academic performance & perceived intelligence or skill in STEM content areas. Includes grades earned*	*138*	*83*	*221*
Interest & liking	*Students' passion for and enjoyment of STEM subject matter. Includes students' desire to choose and persist in STEM*	*212*	*59*	*271*
Positioning	*Students' chosen physical location in the classroom*	*13*	*8*	*21*
Preparation	*Students' prior experience & educational background, particularly in STEM-related areas such as coding or math*	*45*	*51*	*96*
Student responsibility for learning	*Students' self-motivation to learn independently and/or take the initiative to seek help*	*64*	*34*	*98*
Time management	*Students' ability to manage multiple commitments including classes, studying, athletics, employment, etc.*	*61*	*17*	*78*

[1] Themes are listed alphabetically within each category or subcategory.

Instructor factors	***Factors under the control of professors, lecturers, and teaching assistants (TAs) whose instruction directly or indirectly influences student outcomes***	***730***	***374***	***1104***
Assessment & grading practices	*Instructors' methods for assessing and/or grading student performance.*	*200*	*83*	*283*
Enthusiasm	*Instructors' positive attitude toward and passion for STEM topics and course material*	*26*	*8*	*34*
Identity match	*Instructors' social identity match with students*	*3*	*6*	*9*
Instructor reputation	*Instructors' reputation as "good" or "bad;" includes general impressions and information from other students*	*52*	*16*	*68*
Instructor responsibility for learning	*Instructors' roles and responsibilities to teach students effectively in the classroom*	*23*	*23*	*46*
No stupid questions	*Instructors' openness and encouragement of any and all student questions and/or responses in the classroom*	*61*	*19*	*80*
Personality	*Instructors' personality characteristics*	*17*	*1*	*18*
Rules & expectations	*Instructors' explicit or implicit expectations for student conduct in the classroom*	*47*	*37*	*84*
Subject knowledge	*Instructors' knowledge of course content & related subject matter*	*8*	*3*	*11*
Support & care for students	*Instructors' level of caring about students, as evidenced by support, advising behaviors, and availability*	*76*	*84*	*160*
Teaching methods	*Methods & strategies used to set up course instruction; includes lecture, group work, organization of content, etc.*	*196*	*81*	*277*
Teaching vs. research	*Instructor focus on undergraduate teaching or research activities; include mandatory teaching responsibilities*	*21*	*13*	*34*
Class factors	***Factors at the course or classroom level, but not under the direct control of the instructor(s)***	***183***	***68***	***251***
Class size	*Number of students in the course*	*31*	*31*	*62*
Difficulty	*Perceived difficulty of course content*	*131*	*31*	*162*
Physical space	*Classroom and/or location where course is taught*	*21*	*6*	*27*

Department & institution factors	***Influences at the level of the STEM department or educational institution***	***204***	***96***	***300***
Campus resources & supports	*Any resources to support STEM students beyond instructor office hours; includes tutoring, living-learning communities, etc.*	*36*	*31*	*67*
Course schedule & sequence	*Time, location, requirement, and order of courses*	*109*	*45*	*154*
Program reputation & size	*Reputation of a specific department or program in STEM, including number of students*	*15*	*9*	*24*
STEM vs. other majors	*A sense of competition or aggression between STEM and other majors at an educational institution*	*44*	*11*	*55*
Social factors	***Broad-reaching social factors and identities that directly or indirectly influence student outcomes***	***453***	***157***	***610***
Family	*Family influence, including family of origin (i.e., parents, siblings) and family of choice (i.e., partner, children), on student expectations, experiences, and outcomes in STEM majors & careers*	*40*	*14*	*54*
Gender	*Gender influence on representation, expectations, experiences, & outcomes for women in STEM majors & careers*	*166*	*69*	*235*
Nationality & language	*Nationality & linguistic influence on representation, expectations, experiences, & outcomes for international students in STEM majors & careers*	*5*	*2*	*7*
Peers	*Friends' & classmates' influence on student expectations, experiences, & outcomes in STEM majors & careers*	*107*	*10*	*117*
Race & ethnicity	*Racial and ethic influence on representation, expectations, experiences, & outcomes for ALANA and international students in STEM majors & careers*	*68*	*36*	*104*
Socioeconomic status & economy	*Representation, expectations, & experiences of low-, middle-, & high-SES students; includes student jobs, scholarships, & college costs*	*67*	*26*	*93*

Descriptors	Words and phrases used to describe the classroom culture of undergraduate introductory STEM courses	534	201	735
Comfortable & informal	*A relaxed, laid-back classroom culture*	*66*	*15*	*81*
Fun & entertaining	*A humorous, energetic classroom culture*	*26*	*9*	*35*
Helping & collaborative	*A bonded, non-competitive classroom culture*	*55*	*32*	*87*
Engaged & participatory	*An interactive, engaging classroom culture*	*56*	*51*	*107*
Sleepy & non-participatory	*A tired, disengaged classroom culture*	*41*	*20*	*61*
STEM anxiety	*A worried, anxious classroom culture*	*78*	*30*	*108*
Uncomfortable & formal	*A strict, formalized classroom culture*	*59*	*7*	*66*
Weed-out & competitive	*A difficult, grade-driven classroom culture*	*153*	*37*	*190*
Consequences	**Student outcomes related to STEM education**	**935**	**357**	**1292**
Engagement	*Focus & attention paid to course content*	*95*	*50*	*145*
Learning	*Student learning outcomes related to STEM content*	*139*	*41*	*180*
Major choice	*Initial decision to pursue a particular major*	*109*	*26*	*135*
No effect & protective factors	*Little or no effect on outcomes; protection against negative outcomes*	*164*	*31*	*195*
Persistence	*Maintaining enrollment to graduate with a STEM major*	*209*	*104*	*313*
Switching	*Leaving a STEM major to study another major or drop out*	*219*	*105*	*324*

Table 7

Frequency of Themes by Gender and Race/Ethnicity

	Frequency							
Category, *Subcategory*, or *theme*[2]	**White Women (n = 55)**	**White Men (n = 65)**	**Asian Women (n = 13)**	**Asian Men (n = 12)**	**ALANA Women (n = 4)**	**ALANA Men (n = 9)**	**Unreported Women (n = 7)**	**Unreported Men (n = 10)**
Antecedents	**1170**	**1037**	**172**	**187**	**86**	**216**	**141**	**182**
Student factors	363	330	65	72	30	65	50	78
Future career options & earnings	*68*	*65*	*11*	*5*	*5*	*14*	*3*	*9*
Grit & stubbornness	*11*	*10*	*2*	*0*	*4*	*2*	*2*	*1*
Hard work	*26*	*53*	*10*	*10*	*1*	*6*	*11*	*7*
Intelligence & skill	*71*	*58*	*11*	*17*	*6*	*13*	*13*	*16*
Interest & liking	*66*	*91*	*25*	*19*	*7*	*17*	*6*	*19*
Positioning	*9*	*8*	*2*	*2*	*1*	*0*	*0*	*0*
Preparation	*32*	*19*	*2*	*9*	*1*	*5*	*5*	*19*
Student responsibility for learning	*43*	*15*	*1*	*7*	*3*	*3*	*5*	*2*
Time management	*37*	*10*	*1*	*3*	*2*	*4*	*5*	*5*
Instructor factors	***383***	***389***	***47***	***47***	***28***	***95***	***45***	***46***
Assessment & grading practices	*108*	*82*	*9*	*17*	*4*	*20*	*8*	*14*
Enthusiasm	*8*	*11*	*6*	*2*	*1*	*3*	*2*	*1*
Identity match	*3*	*4*	*0*	*0*	*0*	*0*	*0*	*0*
Instructor reputation	*17*	*22*	*2*	*7*	*0*	*7*	*3*	*0*

[2] Themes are listed alphabetically within each category or subcategory.

Instructor responsibility for learning	*19*	*17*	*2*	*3*	*0*	*2*	*2*	*0*
No stupid questions	*22*	*20*	*2*	*4*	*11*	*6*	*3*	*3*
Personality	*6*	*2*	*1*	*0*	*2*	*2*	*0*	*2*
Rules & expectations	*26*	*38*	*2*	*1*	*0*	*9*	*6*	*8*
Subject knowledge	*1*	*9*	*1*	*0*	*0*	*0*	*2*	*0*
Support & care for students	*59*	*53*	*3*	*3*	*3*	*24*	*4*	*9*
Teaching methods	*106*	*114*	*18*	*10*	*5*	*12*	*15*	*8*
Teaching vs. research	*7*	*14*	*1*	*0*	*2*	*9*	*0*	*0*
Class factors	***106***	***54***	***16***	***12***	***18***	***13***	***7***	***19***
Class size	*20*	*20*	*1*	*1*	*7*	*5*	*2*	*4*
Difficulty	*66*	*30*	*12*	*10*	*3*	*8*	*5*	*13*
Physical space	*20*	*4*	*3*	*0*	*8*	*0*	*0*	*2*
Department & institution factors	***105***	***76***	***18***	***18***	***1***	***11***	***15***	***15***
Campus resources & supports	*27*	*18*	*3*	*1*	*0*	*3*	*9*	*0*
Course schedule & sequence	*53*	*41*	*8*	*10*	*1*	*3*	*5*	*13*
Program reputation & size	*10*	*4*	*4*	*4*	*0*	*2*	*0*	*0*
STEM vs. other majors	*14*	*12*	*3*	*1*	*0*	*3*	*1*	*1*
Social factors	***213***	***188***	***26***	***38***	***9***	***32***	***24***	***24***
Family	*18*	*15*	*3*	*3*	*1*	*5*	*4*	*2*
Gender	*79*	*81*	*10*	*16*	*4*	*11*	*9*	*12*
Nationality & language	*2*	*3*	*0*	*0*	*0*	*0*	*0*	*0*
Peers	*62*	*16*	*4*	*10*	*1*	*0*	*1*	*2*
Race & ethnicity	*25*	*41*	*4*	*4*	*0*	*11*	*3*	*3*
Socioeconomic status & economy	*27*	*31*	*4*	*5*	*1*	*5*	*7*	*5*

Descriptors	**261**	**238**	**35**	**35**	**23**	**42**	**31**	**40**
Comfortable & informal	***33***	***20***	***2***	***5***	***5***	***3***	***8***	***7***
Fun & entertaining	***8***	***9***	***2***	***4***	***1***	***8***	***2***	***1***
Helping & collaborative	***18***	***27***	***4***	***2***	***1***	***7***	***2***	***3***
Engaged & participatory	***35***	***55***	***5***	***6***	***2***	***7***	***3***	***5***
Sleepy & non-participatory	***30***	***17***	***7***	***0***	***0***	***3***	***2***	***2***
STEM anxiety	***36***	***29***	***7***	***2***	***2***	***8***	***7***	***8***
Uncomfortable & formal	***6***	***12***	***0***	***1***	***0***	***0***	***0***	***0***
Weed-out & competitive	***70***	***53***	***8***	***11***	***2***	***6***	***7***	***11***
Consequences	**458**	**378**	**74**	**78**	**24**	**87**	**53**	**63**
Engagement	***65***	***38***	***15***	***10***	***6***	***16***	***7***	***4***
Learning	***69***	***56***	***3***	***4***	***5***	***5***	***8***	***6***
Major choice	***41***	***51***	***11***	***10***	***1***	***7***	***1***	***10***
No effect & protective factors	***57***	***63***	***11***	***15***	***5***	***9***	***9***	***12***
Persistence	***91***	***87***	***22***	***20***	***3***	***28***	***16***	***18***
Switching	***135***	***83***	***12***	***19***	***4***	***22***	***12***	***13***

Causal pathways were explored through an understanding of code co-occurrences in the data set as well as via rich descriptive analysis of transcripts. Table 7 displays the number of co-occurrences for 22 codes selected for their frequency and importance to the research questions in the study. This information was used to uncover causal pathways for visualization and rich description of the data.

Table 8

Jaccard Similarity Coefficients for Selected Themes

	Antecedents																Descriptors				Consequences	
	FCE	**HW**	**I&S**	**I&L**	**PRE**	**GR**	**NSQ**	**S&C**	**TM**	**CS**	**DIF**	**R&S**	**S&S**	**GEN**	**R&E**	**SES**	**C&I**	**EP**	**ANX**	**WO**	**PER**	**SWI**
FCE	1	.07	.08	.12	.03	.05	.00	.01	.00	.01	.04	.06	.03	.14	.01	.00	.05	.05	.14	.13	.07	.08
HW		1	.12	.09	.06	.10	.00	.04	.02	.02	.13	.03	.02	.06	.01	.01	.02	.08	.12	.10	0.11	0.08
I&S			1	.12	.08	.22	.01	.05	.04	.01	.07	.11	.06	.06	.00	.01	.08	.07	.13	.18	63	84
I&L				1	.05	.09	.01	.04	.07	.02	.06	.05	.03	.03	.02	.04	.03	.05	.20	.16	99	82
PRE					1	.05	.01	.02	.04	.01	.04	.04	.06	.02	.01	.02	.05	.03	.05	.07	19	27
GR						1	.03	.09	.06	.02	.14	.03	.01	.02	.02	.04	.12	.19	.08	.16	43	82
NSQ							1	.31	.06	.08	.00	.03	.01	.00	.10	.11	.11	.00	.01	.01	4	3
S&C								1	.07	.09	.05	.03	.02	.02	.05	.06	.04	.04	.09	.07	39	33
TM									1	.06	.04	.01	.01	.00	.12	.18	.03	.03	.07	.05	39	30
CS										1	.01	.02	.01	.00	.04	.10	.02	.02	.01	.01	2	5
DIF											1	.01	.01	.04	.02	.01	.06	.14	.07	.12	29	53
R&S												1	.23	.03	.01	.01	.03	.01	.08	.08	25	9
S&S													1	.04	.00	.00	.01	.01	.04	.04	22	43
GEN														1	.00	.00	.00	.01	.08	.06	39	39
R&E															1	.17	.03	.01	.02	.00	16	18
SES																1	.03	.00	.01	.00	31	25
C&I																	1	.05	.05	.07	9	2
EP																		1	.05	.16	4	1
ANX																			1	.10	19	27
WO																				1	26	70
PER																					1	60
SWI																						1

Note: Jaccard similarity coefficient where $J(A,B) = \frac{|A \cap B|}{|A|+|B|-|A \cap B|}$

Antecedents

Student factors
FCE = *Future career options and earnings*
HW = *Hard work*
I&S = *Intelligence and skill*
I&L = *Interest & liking*
PRE = *Preparation*

Instructor factors
NSQ = *No stupid questions*
S&C = *Support and care for students*
TM = *Teaching methods*

Class factors
CS = *Class size*
DIF = *Difficulty*

Department and institution factors
R&S = *Campus resources & supports*
S&S = *Course schedule & sequence*

Social factors
GEN = *Gender*
R&E = *Race and ethnicity*
SES = *Socioeconomic status*

Descriptors
C&I = ***Comfortable and informal***
EP = ***Engaged and participatory***
ANX = ***STEM anxiety***
WO = ***Weed-out and competitive***

Outcomes
PER = ***Persistence***
SWI = ***Switching***

Analysis and Discussion

The themes, frequencies, and co-occurrences inform each of the three research questions in this study. Each research question is focused on one of the broad categories of themes: antecedents, descriptors, and consequences. Here, major themes and causal pathways are explored via rich, descriptive analysis and quotations from participants. Quotes are presented with speaker attributes (race/ethnicity, gender, subject area, and student/instructor status) where possible. Where a participant did not report race/ethnicity, no attribute data are included. Discussion follows regarding the meaning of these findings in the broader context of STEM education.

Research Question 1: How do students and instructors describe the classroom culture of undergraduate introductory STEM courses?

Weed-out and competitive. Students most often labeled the classroom culture in introductory STEM courses as a weed-out culture. “They really want to try to just discourage as many people who don’t think they will be able to continue in the chemical engineering program to I mean, try to continue” (White Female Engineering Student). Students also noticed a feeling of competitiveness among their classmates. “I think just because the class is very rigorous and like, everyone is kind of tacitly competitive with each other,” (Asian Female Engineering Student).

Similar to students, the most frequent descriptor theme among instructors was a weed-out classroom culture. When asked explicitly if there is a weed-out culture in her classroom, one instructor reluctantly replied, “That’s the impression” (White Female Biology Instructor). Instructors discussed a desire to eliminate the intimidating aspects of the STEM classroom culture. “The only thing is I try not to stick to stereotype...try to make things simple, accessible, so that they don't think this is a mystery, this is something you have to be a genius to do" (Male Mathematics Instructor). Still others completely denied that a weed-out or competitive culture existed at all: "I don't think there's that mentality, no" (White Female Chemistry Instructor). No matter their opinion, weed-out culture was a major topic of discussion among instructors.

STEM anxiety. The second most frequent descriptor theme related to the classroom culture was STEM anxiety. Students experienced stress and worry about introductory STEM courses. For example, one student described her introductory physics class as "very stressful" to the point where she felt like, "maybe I'm the only person that thinks I can't handle this" (White Female Biology Student). When students described the idea of STEM anxiety in the classroom culture, they used words such as "scared," "frightened," and "stressed."

Comfortable and informal. Among the classroom culture themes that students felt were encouraging, the most frequent descriptor was comfortable and informal. "In my opinion the culture is really laid back and we talk about how we slept and silly things that don't pertain to class at all" (White Female Biochemistry Student). Students always framed this culture positively:

> I think in terms of culture this is my favorite class. The professors on the first day were both like, "You can call us by our first names," and it's very different than any other classes I've taken—and I like that. (White Female Biology Student)

This comfortable and informal classroom culture was most the commonly discussed classroom culture among students who spoke highly of their introductory STEM courses.

Engaged and participatory. Instructors described encouraging classroom culture differently than did students. For example, instructors described an engaged and participatory culture in the classroom field. "I think actually my classes they are fairly interactive, people seem pretty engaged, they will answer questions . . ." (White Male Chemistry Instructor). This participatory culture was always viewed as encouraging, and is a classroom culture that many instructors in the sample were actively fostering in their classrooms.

Discussion. As expected, both student and instructor participants described the undergraduate introductory STEM courses most frequently as having a weed-out or competitive culture. Seymour and Hewitt (1997) noted that this weed-out mentality is a long-established tradition designed to retain only the students who are most capable and interested. This culture, however, is generally regarded as negative and particularly problematic for the persistence of White women and ALANA students (e.g., Hall & Sandler, 1982; Palmer, Maramba, & Dancy, 2011; Seymour & Hewitt, 1997). For instance, women tend to be less competitive and more cooperative when navigating social situations (Barker, Garvin-Doxas, & Jackson, 2002), and, thus, less likely to thrive in a competitive classroom. Among student participants in this sample, women described discomfort related to feelings of competition in the classroom: "It's kind of like a competitive thing that if you don't have the drive as a female you might feel kind of drowned out by the male presence" (White Female Biochemistry Student). Many ALANA students believe this culture of intimidation reduces confidence in their abilities (Palmer et al., 2011).

The second most frequent descriptor of classroom culture (again, for both student and instructor participants) centered on STEM anxiety. Instructors are aware that the stress level in introductory STEM classrooms is problematic: "I think some students are uncomfortable with that level of stress" (White Male Biology Instructor). When students feel stress or worry about their experience in the classroom, it is not surprising that they would want to switch out of STEM to avoid this negative environment. This may be particularly true for White women and ALANA students. White women and ALANA students experience more chronic stress related to perceived discrimination, which leads to elevated stress responses and negative health outcomes (Pascoe & Richman, 2009). When these underrepresented students enter another stressful environment (i.e., STEM classroom), the discomfort may lead to further negative outcomes.

Although these results indicate that the "weed-out" and competitive culture of most undergraduate introductory STEM courses has remained unchanged for several decades, it is important to note that both students and instructors also generated encouraging descriptor themes to describe the culture of introductory STEM classrooms (e.g., comfortable, collaborative, participatory). Within field theory, these cultural experiences arise from the interactions between actors' individual beliefs, identities, and behaviors in the classroom (Zastavker et al., 2013). The second research question focused on the contributors or "antecedents" to perceptions of both encouraging and discouraging classroom culture in introductory STEM courses.

Research Question 2: What factors do students and instructors describe as contributing to the classroom culture of introductory STEM courses? Students and instructors have slightly different perspectives on which of the antecedent factors described above have the most influence on classroom culture in introductory STEM courses. Participants discussed antecedent factors as either directly influencing student outcomes or as contributing to classroom culture and thus indirectly affecting student outcomes. For the sake of continuity, students' ideas are described alongside instructors' for comparison and contrast within themes. The strongest causal pathways, as evidenced by the frequency, co-occurrences, and transcript storylines, are described and discussed.

Student factors. Among student participants, the most commonly-cited antecedent factors for classroom culture, and, ultimately, for student outcomes, were internal factors related to the students themselves (labeled "student factors" in Table 6). Students' interests, skills, and career aspirations comprised the most frequent sub-themes, as explained below.

Interest and liking. The most widely discussed antecedent factor was students' interest in STEM content and material. Although student interest in STEM does not necessarily contribute to classroom culture, it does function as an encouraging and protective factor that prevents switching. "I think what I bring to it is just the interest level, so, if I'm interested in the subject it's gonna be fine," (Asian Female Biology Student). Other antecedent factors such as harsh assessment grading practices, however, diminish student interest in STEM and the likelihood of persisting. "I think it makes me slightly more interested to continue, um, being chemical engineering. But then like, I mean, the grades are kind of discouraging" (White Female Engineering Student).

Intelligence and skill. Instructors emphasized students' intelligence or skills as an antecedent for switching versus persisting in STEM: "Once they realize they just don't have the ability to engage the concepts. And they made a smart choice, they can't do that and they are going to go find a better place to be" (White Male Engineering Instructor). It's "the smarter students, or the ones that have higher grades" (Native American Male Computer Science Instructor) who tend to persist to a STEM degree and career.

From the students' perspectives, acknowledgement of uniformly high intelligence and ability—combined with harsh grading practices—serve to diminish students' confidence and create a competitive and stressful classroom culture:

> Because obviously, if we're in chemical engineering, we're all probably pretty smart. So if we were all getting the scores we're used to, like in the 90s, that would probably I guess, give us a little more confidence going into the test. However, it obviously doesn't weed out the people that the program wants it to–doing–grading that way. (White Female Engineering Student)

For a group of highly capable and intelligent students, instructors' tough assessment and grading practices can have a negative impact on classroom culture.

Future career options and earnings. According to students, the economic prosperity and esteem in STEM careers can contribute a competitive air to the classroom culture of introductory STEM courses. One participant reported, "it's competitive in the sense that a lot of us want, you know, the higher-end academic jobs. As far as job security in this field we're pretty good" (Latino Computer Science Major). The opportunity to enter a well-respected and lucrative career field can also have a positive influence on students' propensity for choosing and persisting in STEM majors. "Money is a deciding factor in a lot of things. Especially like, concerning schooling and what you go into" (White Female Biology Student). On one hand, students' future career aspirations might contribute to a competitive classroom culture; on the other, these same aspirations can serve as an encouraging, protective factor for an individual who is considering switching but is motivated to persist because of the potential for earning more money later on.

Hard work. Instructors emphasized hard work as a deterrent for some students in introductory STEM courses:

> I mean, things weren't maybe at the level that is expected when you get to college, and it seems easy for them, and soon as they hit something that's hard, they don't wanna keep working at, or they feel like, "If I have to work at this, then I'm not good at it, and I should do something else." (White Female Chemistry Instructor)

Even for some of the highest achieving students, the hard work in undergraduate STEM courses is a contributor to weed-out and competitive classroom culture.

Students talked about hard work as “a mental endurance test” to weed out those who can’t make it in STEM, “because you have to do all that reading and all that comprehending of all the mechanisms and why reactions go the way they do,” (White Male Engineering Student). One student even noted, “I guess that is our culture of the STEM majors that we’re trying harder,” (White Male Neuroscience Student). Hard work is worn like a medal of honor to promote competition.

Preparation. In comparison to students, instructors were more focused on students’ prior learning as it related to persistence in STEM. “I believe without that good preparation in high school, it would be impossible to change the outcome of what's happening at the college level” (Male Mathematics Instructor). This lack of preparation is blamed for low skill levels and poor outcomes for students in introductory STEM courses.

Instructor factors. Instructor-level factors, particularly grading practices and teaching methods, were also cited as important to developing either an encouraging or discouraging classroom culture for students.

Assessment and grading practices. The traditional grading scheme in introductory STEM courses is designed to weed out a certain number of students. “'Cause they have a bell curve, and they're like, ‘this percent of people are gonna fail; this percent of people are gonna pass’" (White Female Biology Student). Participants reported that pressure and stress about this unforgiving grading system contributes to a stressful classroom culture. “I mean for me knowing how hard this class is and all the work you have to do and once you get back your first test scores and everything it kind of scares you” (White Female Biology Student).

Much like the student participants, instructors also pointed to assessment and grading practices as creating a competitive and stressful classroom culture. One instructor described the way that competition puts more pressure on students to earn high grades in a stressful environment:

> And so, again, because it's such a large proportion of our students who are at least initially going to medical school, that uh, they, I don't know if this is the case or not but I think they interpret a B as the death note. The B they might get in their introductory biology course is the death note for that dream. And so, in a challenging course, if they don't do so well, I think they might decide, "I need to do something else," and to be perfectly honest, I don't know if that's a reasonable decision or not. (White Male Biology Instructor)

While instructors don’t necessarily support the logic of low grades leading to switching, the decision to switch away from STEM is certainly supported by students’ emphasis on grades and the development of weed-out culture.

Teaching methods. Teaching methods, such as lecture or group work, play a major role in developing classroom culture. Students overwhelmingly preferred group work and active learning to traditional lecture instruction. “Part of it is like group work time so everybody's talking amongst themselves for a good portion of the class, and it's not where you sit quietly and watch the teacher talk” (White Female Undecided Student). Moreover, lecture instruction was faulted for contributing to a non-participatory classroom culture. “’Cause other lectures that I heave we just sit down and listen to the lecture. You can only ask a question or two and even if you go to their office hours it's kind of really awkward” (Middle Eastern Male Engineering Student).

The teaching methods theme in this study also encompassed specific pedagogical moves that teachers use in the classroom. Students noted that instructor movement through the class could contribute to a comfortable and informal classroom culture. “And throughout that she walks between the tables and you know you could be like ‘Oh, hey Dr. X,’ as she’s walking by so it’s really informal and you can just ask her questions” (White Female Undecided Student).

Similar to students, instructors referenced certain teaching methods and strategies as contributing to classroom culture in either positive or negative ways. “I think the culture of group work is something that is so important and ultimately the culture of kind of nurturing instead of trial by fire or trial by ordeal” (White Male Engineering Instructor). Another pedagogical strategy, humor, also had a positive effect on classroom culture:

> I like to joke in my classes a lot because life is short and some, why not. If you can convey, I like to joke about that. If you can create that atmosphere it makes it a little bit unique. It makes a culture of how the classroom operates. You see we have a serious thing to do but there is like a relaxed component. At least I try. (Latino Computer Science Instructor)

These instructors were intentional in choosing their teaching practices to foster a more comfortable, informal classroom culture for their students.

Support and care for students. Students reported that supportive, caring behaviors from instructors both inside and outside the classroom create a more comfortable classroom culture. “I think it’s important that the people, whether it's professors or TA's, are passionate and they generally care about the people they’re teaching . . .” (White Male Engineering Student). If instructors do not offer enough support and resources, students feel even more upset:

> I’ve spent an hour in office hours. I’m like completely paranoid at this point. Like, I feel like I’m hitting [a] random number generator to get answers and they’re probably wrong anyway and then I’m going to find out on the exam that they’re wrong and then I’m going to be totally pissed off . . . (White Male Engineering Student)

It is clear that instructors also recognized the need for supportive and caring interactions with students. Instructors described this caring demeanor as a way of developing a comfortable classroom culture:

> If they need help they need to feel like they are able to approach me and I need to be an approachable figure . . . not that I'm going to be their best friend but that I am a caring enough individual to care about what is going on in their lives that they can be able to approach me. (White Male Engineering Instructor)

Instructors demonstrated their care for their students in many ways, such as bringing candy, learning names, and being available for questions after class. All of these supportive and caring behaviors contributed to a comfortable classroom culture.

Class factors. Class-level factors, particularly difficulty, were deemed critical for determining classroom culture.

Difficulty. Students expressed that the overall difficulty level of introductory STEM courses contributed to a general level discomfort. “Calc is definitely my hardest class by far compared to all the other classes I'm taking but so I do feel kind of out of place when I'm in there...” (African American Male Biochemistry Student) Course difficulty can also directly contribute to students’ decisions to switch out of a STEM major. “I think part of the reason maybe people might switch out of chemical engineering or any science or engineering major is because of how rigorous the classes are . . .” (Asian Female Engineering Student)

Instructors also recognize that the difficulty level of the course has a negative impact on students’ attitudes. One instructor laughed, “ . . . I think half the class is like, ‘Oh this class is so hard and why am I sitting here learning this? I’m just gonna get another 60 percent on my exam,” (White Male Chemistry Instructor). Course difficulty was generally discussed in the context of difficult content and a harsh grading system, which both contribute to a weed-out or competitive culture in introductory STEM courses.

Department and institution factors. Study participants also identified department- or institution-level influences on STEM classroom, including campus resources and supports as well as course schedule and sequence.

Course schedule and sequence. The timing and course sequence comprised the most frequent sub-theme related to department and institution factors. Students complained that early morning classes are sleepy, tired, and disengaged. “I do notice that it’s kind of uh, it, people tend to fall asleep. I notice a lot of people like, on their phones or on their computers, not exactly paying attention” (White Female Biology Student). Some instructors noticed these behaviors as well. “I used to be offended by people who slept in my class, but I’m not anymore because I realize if they’re that tired and they come to my class anyway I should be flattered” (White Male Chemistry Instructor).

Instructors focused on the sequencing of courses, especially mathematics courses. “They can't pass a math class, so they—this has the consequence of whether or not they can keep up with the schedule to take the main engineering class they need to take in order to graduate (Male Mathematics Instructor). Instructors also described the different groups of students who contributed to unique classroom cultures at different points in the academic year. “There’s a difference between fall and spring in the second semester...

The stronger students are usually on sequence. They're taking the second semester in the spring, instead of the fall" (White Female Chemistry Instructor).

Campus resources and supports. When asked about how STEM departments can improve, students asked for more resources and supports. "I'd say probably create more resources for more personalized help so that like one person like Igor said isn't sitting in the background not really knowing what's going on, not having enough help and stuff" (White Female Engineering Student). These supports further emphasize an encouraging, comfortable, and helpful culture instead of a culture of individualized competition.

Instructors had similar views on campus resources and supports. When asked how to improve STEM outcomes, one instructor replied, "I think more...support. And in especially—well probably in all phases of the major—um, the idea—you know, making the idea of failure and frustration acceptable" (White Male Physics Instructor). Instructors hoped that increased resources would combat some of the course difficulty and harsh grading to promote more persistence among STEM undergraduates.

Social factors. Social identity factors (including gender, race/ethnicity, and socioeconomic status) were described as having variable effects on classroom culture and persistence decisions.

Gender. Student participants were generally open and candid about their understanding of gender issues in STEM fields. "I feel like one of the main reasons, I actually was an engineering student before I chose biochemistry and I felt very uncomfortable as a female in the engineering field" (White Female Biochemistry Student). Both male and female students recognized that being outnumbered was a key component of women's discomfort in STEM. "Um, well, I don't have any personal views as a White male of middle class. But being a member of our at least—our science college, the CSE here, is sort of a boy's club, even though it isn't't" (White Male Computer Science Student).

Students also noted that gendered socialization shapes major choice much earlier than the first introductory STEM course:

> I think that part of it's a cultural thing that like as we grow up we kinda just assume that like, oh, boys are gonna play with like the trucks and like the Legos and like build all these things . . . (White Female Biochemistry Student)

There was also recognition that women are not traditionally expected to be breadwinners, and have more financial flexibility to choose majors that are not as lucrative:

> I think that engineers make good money, but female [students] don't need to worry about making money as much as males so maybe some female students would like to do something else like do something they are really interested in but, that may have less promise future. (Asian Female Engineering Student)

Men and women responded differently to focus-group interview questions about gender. Several men took gender-blind viewpoint: "I've never seen them have any extra trouble or benefits from being that, different in that way . . ." (White Male Computer Science Student). Some women also reported no concerns related to uncomfortable gendered interactions:

> I mean, I haven't noticed any sort of like level of disrespect because I'm a woman. I mean I'm sure there's probably situations out there where women are, you know, like not taken seriously, but I personally haven't experienced any of it.
>
> (White Female Engineering Student)

A number of women even cited gender as a motivator for their persistence in STEM:

> Certainly there are a lot less female [students] in the engineering classes, and that's actually encouraged me a lot 'cause every time people ask me my major I say, "I'm majoring in chemical engineering," they will say, "Oh there are not a lot of girls majoring in chemical engineering," and that's a really great motivation for me to continue for this major. (Asian Female Engineering Student)

Instructors echoed students' beliefs that the underrepresentation of women can be a critical factor influencing discomfort in STEM and, ultimately, leading to switching. For some instructors, the changes in the gendered composition of the class indicate that this underrepresentation and lack of comfort is no longer an issue. "I think women are more than half my class now. So I think there is a built-in support system there now" (White Female Chemistry Instructor). Others noted that historical gender roles still influence gendered interactions today: "Women were supposed to stay home right? And men went out and got all the jobs so. Um. I think it's you know, just kind of shifting still" (White Male Chemistry Instructor). Overall, gender was a widely discussed antecedent factor with a major impact on both classroom culture as well as student outcomes such as major choice and persistence.

Peers. It is clear from participants that friends and classmates can promote a competitive or collaborative classroom culture:

> ...I think just because the class is very rigorous and like, everyone is kind of tacitly competitive with each other. So we do try to help each other out, but at the same time, I think everyone is also trying to like, aim for the highest score. (Indian Female Engineering Student)

Instructors hope that students turn to each other for collaborative support:

> All of us are gonna struggle with some particular types of content but that's not the same content that somebody else is gonna struggle with, so hearing from somebody else, and not looking to the instructor is the, the oracle, the font of all knowledge, rather somebody else, that YOU serving in that role for somebody else, when you understand particular material. I think we see that as students leave our course that continues throughout the rest of the academic career, what our students have here. (White Male Biology Instructor)

The relationships and friendships built with peers in STEM introductory courses are influential for both classroom culture and critical student outcomes.

Race and ethnicity. Overall, participants' discussion of race, ethnicity, and the relationship with classroom culture and persistence decisions was shallow and did not point to clear causal pathways toward the development of a specific classroom culture. Students were more reluctant to talk about race than they were about gender or peers:

> There are like really about the same ratio of minorities in general, but at least of Black or African or whatever you want to say it, there really is like a very few, of us quote unquote I don't really feel comfortable saying that I guess but I guess it kind of it discourages me and encourages me I guess in a way it discourages me cause I feel out of place, also like it encourages me, it motivates me because I have to prove myself and I really want to prove myself so like it's not like this sense of he can't do it or whatever, because of whatever outside factors you want to call. (African American Male Computer Science Student)

Student participants also talked about the recent societal push toward multiculturalism and racial/ethnic diversity, especially in relation to affirmative action policies at institutions of higher education. White students, in particular, noted that this felt like a disadvantage:

> As a Caucasian male, being in the majority, I feel like definitely, I feel like affirmative action has hit me a little bit and you hear horror stories from around the nation where some people get advantages or disadvantages due to race. And I don't know, I guess this is just me- this is, I don't know, I hate to have race into anything, but I feel discriminated against, at least a little bit. (White Male Engineering Student)

Still others took a color-blind, post-racial approach:

> I think times have changed, I think at the point where anyone can do anything that they want as long as they're successful. I was considering doing some sort- like I mentioned earlier, I was considering doing a music major, just cause I enjoyed music, but it's whatever you want at this point. (Female Biology Student)

Similar to students, instructors talked about the opportunities available for all underrepresented social identity groups rather than the issues facing ALANA students in STEM:

> You know, you're um- we have special scholarships, internships, positions, and things for people of color and especially for women of color um and they are- and

> like for engineering and you know for other STEM fields there are very key thing that are just for that group of people so that there's encouragement there as well. (White Female Biology Instructor)

Instructors also advocated for a color-blind approach to students' sense of belonging in STEM:

> I hope we break them and help them form a more healthy scientific perspective of who they can be as a scientist and not see themself as a scientist of color or a scien—a woman scientist but as a scientist in general. (White Female Biology Instructor)

Race and ethnicity were usually grouped with other social identities rather than discussed as a unique antecedent factor.

Socioeconomic status and economy. When students discussed socioeconomic status (SES), they included other social identities as well:

> I think that the sciences have done a great job in offering opportunities to people of different ethnicities and races and things like that, financial backgrounds, everything. And actually I think that a lot of times people, um minorities, and people with financial, um, problems, often have more opportunities. (White Female Biology Student)

Low SES was also cited as having a negative impact on the resources and time that students could dedicate to studying for introductory STEM courses. One student shared:

> I'm a low-income student; I get food stamps. I do not have money to get a tutor, and there are plenty of students in my class who have tutors and see their tutors probably three times a week. That's not fair. (Student)

For instructors, SES was associated with holding a job while studying a STEM major:

> They're all trying to work three jobs and go to school. I mean all I did was go to school. I don't know how you can—they all seem to have financial burden, and-and minorities in particular usually have that struggle a little more. (White Female Chemistry Instructor)

Although SES was not discussed as having a direct impact on classroom culture, it was described as a factor that, along with race ethnicity, certainly influences persistence in STEM.

Discussion. A number of student, instructor, class, department/institution, and social factors have some level of influence on the classroom culture of introductory STEM courses. Both students and instructors, as the actors in the classroom field, influence the classroom culture with their interactions. Classroom, institution/department, and social factors also have an impact on classroom culture, although less so.

Student characteristics (e.g., interest, aspirations, preparation) and behaviors (e.g., hard work) shape the ways students interact within the classroom field. Interest in STEM was cited as a protective factor against the often competitive and stressful classroom culture in introductory STEM courses. Unfortunately, this protective factor is not equitably distributed among STEM undergraduates. A lack of interest, for example, accounts for some of the gender disproportionality in STEM fields (Sax, Jacobs, & Riggers, 2010a). More specifically, women are more likely than men to be interested in careers that are congruent with their endorsement of communal goals (Diekman et al., 2010). This diminished interest in STEM may contribute to women's underrepresentation and discomfort in introductory STEM classrooms.

Career goals and aspirations contribute both to a competitive classroom environment, and, for those with a competitive streak, a propensity for choosing and persisting in STEM majors. Much of the participants' discussion about future career interests was centered on money, with is more of a motivator for some groups than others. Seymour and Hewitt (1997) noted that because women are not culturally obligated to provide financial stability for their family, they might be motivated more by their interest than by the potential for higher earnings in STEM.

Hard work both during and outside of class is important for student persistence no matter the classroom culture. Hard work, however, is also a contributor to the weed-out and competitive culture in introductory STEM courses. Some students were frightened away by the work, whereas others viewed it as a mark of the rigor of STEM courses and majors. Marginalized groups, and particularly ALANA women, are more likely to experience a lack of academic rigor in secondary school that can make undergraduate-level work more difficult and time consuming (Malcom et al., 1976).

Instructors blame students' previous preparation, particularly in mathematics, for contributing to discomfort and, ultimately, switching away from STEM. Students recognize how previous experiences influence major choice, but lack the instructors' perspective on how a lack of preparation could emphasize the weed-out and competitive culture in STEM. Research suggests a lack of positive experiences and preparation in science and mathematics affects educational and career decisions among women in particular (Blickenstaff, 2005).

In this study, instructor factors were directly implicated in the development of classroom culture. Consistent with Seymour and Hewitt (1997), assessment and grading practices contributed to a weed-out culture. Instructors' caring and supportive behaviors, on the other hand, contributed to a comfortable classroom culture. These caring and supportive behaviors may be positive, but also distributed inequitably. For instance, ALANA students describe a lack of support from instructors (Seymour & Hewitt, 1997), which certainly influences how positively the classroom culture is viewed.

Participants noted that teaching methods have either an encouraging or discouraging impact on the classroom culture. Lecture-based teaching methods create a stressful culture, whereas group work develops a comfortable culture. These factors account for how White women and ALANA students experience the classroom culture. For example, women prefer classes with many hands-on demonstrations and group activities (Persaud et al., 2006).

Classroom factors also account for a negative classroom culture. Course difficulty contributes a culture of harsh competition. This is especially problematic for ALANA students, who generally feel that intimidation in STEM classrooms undermines their confidence (Palmer et al., 2011). According to participants, large class sizes contribute to students' anxiety in the classroom. This may be particularly true for women, who tend to prefer small classes (Persaud et al., 2006).

Social factors, particularly social identities and interactions with peers, also contribute to classroom culture. Participants were generally aware that White women and ALANA students are underrepresented in STEM majors and careers. There was a strong focus on the underrepresentation of White women and ALANA students as contributing to these groups' discomfort in the classroom. This line of reasoning aligns well with Seymour and Hewitt's (1997) finding that students from underrepresented social identity groups felt more comfortable in classes when they were not outnumbered.

Participants also focused on the opportunities that White women and ALANA students have in STEM due to their status as underrepresented students. Students and instructors called for a gender-blind and color-blind approach to recruiting and retaining students in STEM; conversations about social justice and equity were limited. The viewpoint that science is a neutral meritocracy is especially damaging for ALANA women in STEM (A. C. Johnson, 2007), as it invalidates social identities as critical components of students' lived experience. Previous research suggests social identities, participatory trajectories, and learning opportunities are inextricably interrelated (Oppland, 2010b), and, therefore, these social factors should not be ignored.

This study supports the idea that peers have a substantial impact on the way STEM fields and classrooms are perceived. Participants noted that peers and classmates can have either an encouraging or discouraging impact on classroom culture. Based on previous research, women report that treatment from their male peers in STEM courses and departments often leads to a negative classroom culture (Cabrera et al., 2001). In contrast, instructors in this sample pointed to peer collaboration as an important factor in fostering a comfortable classroom culture. Men who experience STEM courses that are inhospitable to women may find it difficult to perceive women as equal peers, to work with them in collaborative learning situations, and to offer them support as colleagues in academic or professional settings (Hall & Sandler, 1982). Promoting peer collaboration across social identity groups may be beneficial for the culture of classrooms and workplaces.

Students and instructors agreed that a lack of financial resources can make STEM persistence more difficult. This finding aligns with research that suggests low SES has a negative impact on STEM degree attainment (Wilson et al., 2012). Although SES was not described as a contributing factor in classroom culture development, participants had an understanding of how it might influence student outcomes in STEM.

Participants' understanding of how classroom culture is developed aligns closely with Zastavker and colleagues' (2013) idea that students and instructors construct classroom culture through their interactions in the classroom. The piece that appears to be missing, however, is these actors' goals, perceptions, interpretations, and social, institutional, and situational positioning (see Figure 1, p. 44). Many participants were only vaguely aware of the ways that student and instructor identities (e.g., gender, race & ethnicity) influence the meaning of interactions, and ultimately, the classroom's culture. Nevertheless, participant responses point to a number of interventions that might help to improve classroom culture and to mitigate the effects that negative classroom culture might have on later student outcomes.

Research Question 3: How do students and instructors report that classroom culture, including cultural congruity or incongruity, of introductory STEM courses influences student thinking about decisions related to persistence in and switching away from STEM majors? Participants in the current study converged on persistence and switching as student outcomes, and often discussed these two phenomena simultaneously.

Switching. For students, the type of classroom culture most commonly associated with switching was weed-out or competitive culture. A weed-out course urges students to switch out if they can't handle the rigor: "I feel like they're trying to tell you, like if you can't handle this class, you're not going to be able to handle the future ones either" (White Female Engineering Student). The difficulty of the course, which leads to a sense of competition among students, is also a signal for students switch out of the course or major.

Instructors also believe that a competitive and stressful classroom culture influences student persistence. One instructor spoke from her own experience as a chemistry student:

> High school was easy for me, and I got to my first semester of chemistry, and I think I was worried I wasn't gonna pass. I went, "Uh. Maybe I shouldn't be a chemistry major if I can't even pass Gen Chem I," you know? (White Female Chemistry Instructor)

Furthermore, discussion of weed-out culture and switching was more common among White women than among White men in the sample (see Table 7). This finding suggests that White women are more likely than their male peers to take notice and feel pushed out by the weed-out and competitive culture encountered in introductory STEM courses.

A second theme related to classroom culture, STEM anxiety, is a major reason for dropping an introductory STEM course or leaving a STEM major altogether. Students who received poor grades in introductory courses worried that this pattern of low performance would continue: " . . . if you screw up in the beginning, you're like, 'I'm gonna continue screwing up so I'm just gonna drop it from here'" (Middle Eastern Male Engineering Student). STEM anxiety ultimately leads to switching out of STEM.

This stressful environment can be particularly problematic for women:

> I know there was a statistic that like girl engineering majors tend to drop out because they have A and B GPAs whereas guy engineering majors drop out because they have Ds and Cs and this was a question raised in one of my discussion classes like why do you think that is and it's probably because girls feel like they have to prove themselves twice as much like a lot of my guy friends are very easy like they're very relaxed with having a C average in a class whereas I'm like no I can't have a C I have to have a B+ and they're like your GPA is higher

> and I'm like no I need to! And I don't know why—it just bothers me. (Female Engineering Student)

White women also talked about STEM anxiety more frequently than did White Men (see Table 7), indicating more feelings of worry and fearfulness among this group. ALANA men may also struggle with feelings of STEM anxiety in these courses; 8 of 9 ALANA men in the sample mentioned STEM anxiety in our interviews.

Persistence. Whereas a negative classroom culture contributes to students' thinking about switching, a culture of comfort and belonging in STEM is more likely to lead to persistence:

> I think the culture of this class is really different from the culture of the classes I took last year. They were just the general classes and I feel all the people are doing different things, majoring different area. So I feel I belong to this class more 'cause I know everyone is doing the same major and I feel really good to be on the right track. So I really enjoy the culture of this class. (Asian Female Engineering Student)

Again, comfortable and informal classroom culture was a theme emphasized more frequently by White women than by White men in this sample (see Table 7), indicating that there may be a gendered component to this culture's protective effects.

Instructors emphasized the importance of a positive classroom culture for student behavior and persistence:

> If you are in an environment where you know you're liked and you know it's not an adversarial sort of spirit around, then it releases you to maybe go further than you think you can. So you push. (White Female Biology Instructor)

Instructors also focused on engagement in the classroom field as a component of this positive culture. " . . . if the students have a good comfort level., then they're more prone to interacting and participating." (Male Mathematics Instructor). White men were more likely than White women to discuss engaged and participatory culture, which points to the mostly White male instructors' focus on engaging students in order to promote learning and, ultimately, persistence in STEM.

Discussion. On the whole, both students and instructors agreed that weed-out, competitive, stressful, and anxiety-provoking classroom culture leads to switching away from STEM. The discomfort associated with this negative classroom culture is problematic for many STEM undergraduates, but particularly for White women and ALANA students; students' preferred culture of comfort and informality clashes glaringly with the traditional competitive and stressful culture, which is amplified for underrepresented students in a multitude of ways.

Many women have limited interest in STEM content (Sax, Jacobs & Riggers, 2010) and careers (Diekman, Brown, Johnston, & Clark, 2010). Women also miss out on a number of positive experiences in science and mathematics (Blickenstaff, 2005). When a woman does make it into an introductory STEM classroom, she is typically faced with a large, lecture-style course with few opportunities for interaction with others; both of these are incongruent with women's preferences (Persaud, et al., 2006). Herein lies the culture clash; preferences for classroom culture are violated and an individual's likelihood for persistence in STEM is reduced in the absence of any protective factors.

For ALANA students, the discomfort present in STEM classes may be amplified. An ALANA student who declares a STEM major is met with a culture of competition and intimidation that undermines his confidence (Palmer et al., 2011). When the student asks for help, he is often met with a lack of supportive and caring behaviors from instructors (Seymour & Hewitt, 1997). This study points to competitive culture and supportive instructors as critical to students' decisions about persistence and switching.

For ALANA women, the likelihood of experiencing all of the above problems is ominous. ALANA women are more likely than their peers to experience a lack of academic rigor to prepare them for the difficulty of STEM course content (Malcom et al., 1976). The compounding of antecedent factors that have a negative impact on the experience of classroom culture may contribute to disproportionate switching patterns.

Despite these challenges, it is possible for White women and ALANA students to choose, persist, and thrive in STEM. Protective factors help students to overcome the effects of negative classroom culture and reach positive outcomes such as engagement, learning, and ultimately, persistence. For example, participants in this study described comfortable and participatory classroom cultures that promote STEM persistence. Students who described feeling comfortable in the classroom reported that they were more likely to persist in their chosen STEM major than if they felt uncomfortable. Instructors who worked for a participatory classroom culture also noticed that students were more likely to remain engaged and enrolled in STEM coursework.

The causal pathways described by participants in this study suggest that a number of antecedent factors have an impact on the development of classroom culture as well as student decisions to persist in STEM. That is, students describe a number of ways that both positive and negative classroom culture might develop, and a number of ways that student outcomes such as persistence and switching might occur. For example, a major causal pathway derived from participant themes is that harsh assessment and grading practices contribute to weed-out and competitive culture, which pushes students to think about switching away from STEM. Another causal pathway is that instructor teaching methods such as the use of humor contributes to a comfortable and informal classroom culture, which encourages students to persist in STEM.

As students travel different pathways, their social identities and classroom culture preferences alter how each of these factors influences student experiences in the introductory STEM classroom. When a White male student enters the field of an introductory STEM classroom, his experience is much different than if he were an African American male or a White female student. Each student brings a unique set of goals, perceptions, interpretations, identities, and experiences into the introductory STEM classroom, which influence both the classroom culture as well as the students' decisions to persist in or switch away from a STEM major.

A selected sample of these causal pathways is illustrated in Figure 2. This diagram depicts just a few of the pathways that lead students from antecedent behaviors through the experience of a particular culture to the final decision to persist in or switch away from a STEM major.

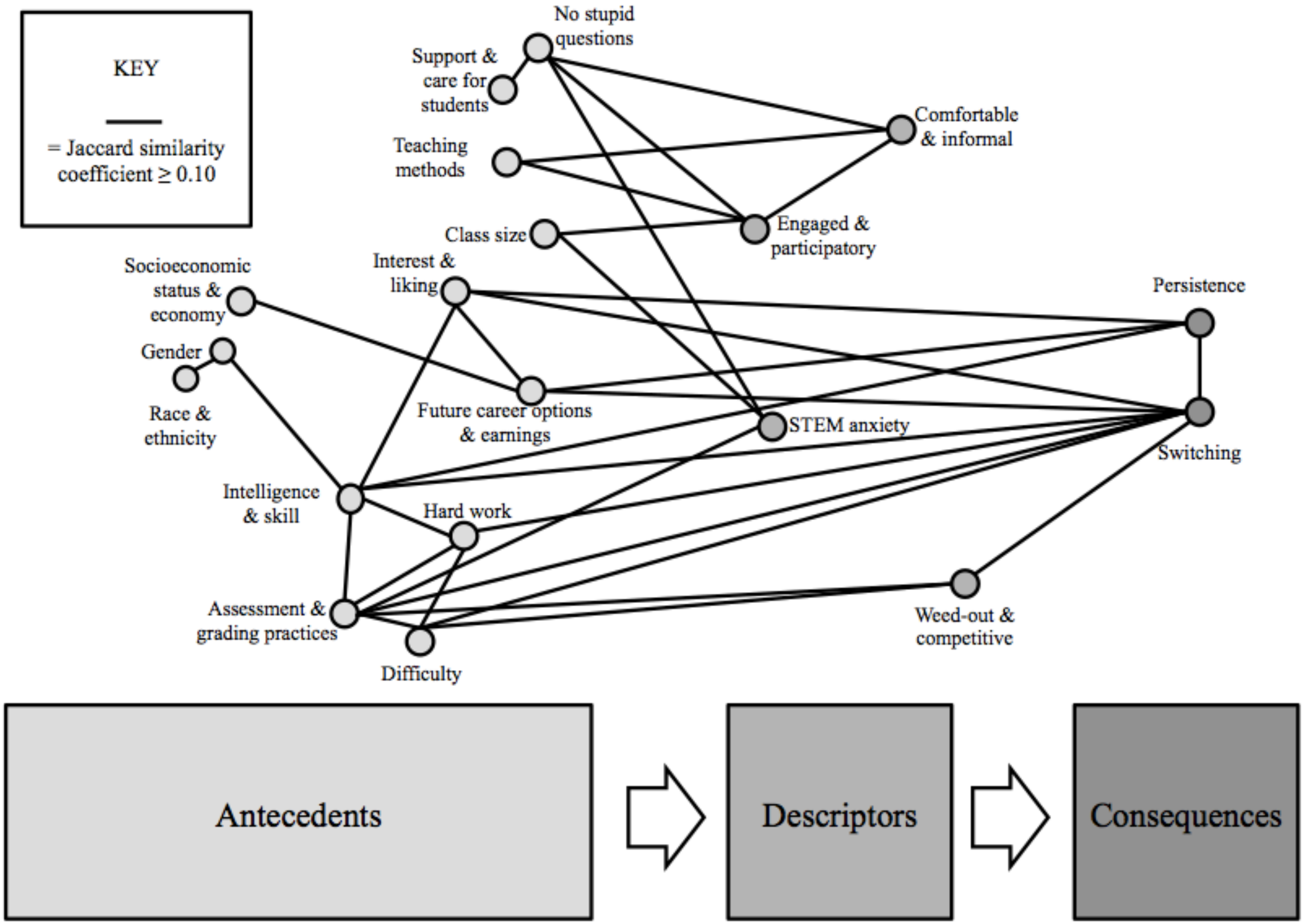

Figure 2. Causal pathways for selected themes.

Chapter 5: Conclusion

Summary

This study was designed to describe and explore the influences of classroom culture in introductory STEM courses on persistence and switching among undergraduate students. Results answered three critical questions: How do students and instructors describe the classroom culture in introductory STEM courses? What factors contribute the classroom culture? What are the outcomes of the classroom culture, and, more specifically, how does cultural congruity and incongruity influence persistence and switching decisions among White women and ALANA students? To address these questions, the research adopted a field theory perspective, which situates students and instructors as actors in the classroom field. Both students and instructors served as informants, and qualitative analysis revealed major themes and causal pathways. New findings and implications are summarized and described below.

New Contributions

A key contribution arising from this study is that classroom culture, whether viewed as encouraging or discouraging, is a construct that exists in the minds of the students and instructors in introductory STEM classrooms. This culture may be intentionally cultivated or may arise spontaneously from everyday social interactions. There is a distinct culture in every classroom, as well as a broader, overarching culture attributed to undergraduate introductory STEM courses overall.

The causal pathway structure of antecedent, descriptor, and consequence themes is a unique and informative framework for understanding both the development of classroom culture as well as student outcomes in STEM. This conceptualization allows the evaluation of specific factors and causal pathways to facilitate the research to practice link. That is, the thematic structure of this qualitative study has the potential to both guide future research and educational practices in STEM.

In this study, classroom culture in introductory STEM courses was most frequently described as a weed-out or competitive culture. This classroom culture is consistent with previous research and with the author's prediction. A related descriptor was STEM anxiety, which students linked to specific aspects of the classroom environment that evoked worry, fear, or discomfort. Relatedly, White women in the sample more frequently mentioned both weed-out culture and STEM anxiety when compared to their White male peers. This critical finding suggests that not only are introductory STEM courses characterized as competitive and anxiety provoking, but that these feelings are disproportionately affecting White women.

Not all of the classrooms were described negatively; students expressed a preference for comfortable, informal classroom culture, while instructors favored an engaged and participatory classroom culture. Again, White women were more likely to talk about a comfortable and informal classroom culture when compared to their White male peers, suggesting that one way of combating the gender gap in STEM is to create more comfortable classrooms, which are noticed more frequently by women than by men. These descriptors give voice to the lived experience of actors (i.e., students and instructors) in the classroom field, and provide insight into the classroom culture of introductory STEM courses at present.

This study makes unique contributions that support and extend previous research about factors that influence classroom culture. Findings suggest that students and instructors, i.e., the actors in the classroom field, directly influence the classroom culture. Participants delineated a number of factors related to student and instructor characteristics and/or behaviors that affect the culture of introductory STEM courses and, ultimately, lead toward either positive or negative outcomes. Other factors, including class-, department-, and institution-level factors, also contribute to positive or negative classroom culture and/or student outcomes. Critical social factors, such as gender, race, peers, and SES, were highlighted as influencing participants' experiences within the classroom environment and STEM fields overall.

Participants attributed the outcomes of persistence and switching to factors related to the actors and the culture created in the classroom field. For example, switching away from STEM is attributed to a weed-out, competitive, and stressful classroom culture often found in introductory STEM courses. Switching is also influenced by student and instructor factors such as lack of preparation (students) or lack of supportive and caring behaviors (instructors). This culture (created by actors within the field) affects students' desire and ability to persist in STEM. White women discussed switching more frequently than did White men, suggesting that this group is more likely to consider switching away from STEM. Conversely, study participants credited persistence in STEM to a comfortable and engaged classroom culture (again, created by individual "actors" within the classroom), which was found in fewer classrooms in the sample.

Finally, this study points to the presence of cultural incongruity in the current classroom culture of introductory STEM courses. For many students, especially White women, there appears to be a culture clash between the preferred and experienced classroom culture in these courses. While there were not enough ALANA students to confidently suggest clear patterns of cultural incongruence, a number of elements that participants highlighted contribute to a competitive, weed-out, or stressful classroom culture. These elements may have a differential influence on these underrepresented students. Overall, there is a need to reduce the amount of stress and anxiety in introductory STEM courses to potentially increase the number of students, especially White women and ALANA students, who choose and persist in STEM majors.

Recommendations

Ultimately, the classroom culture that most students and instructors prefer is characterized by comfort, informality, and student participation. The development of this type of classroom culture is heavily influenced by the interactions between students and instructors in the classroom field, as well as by classroom, department, institution, and broader social factors. The antecedent factors revealed in this study point to critical intervention points for STEM educators and administrators to work toward a more positive classroom culture that can promote persistence for all STEM undergraduates, and may be particularly beneficial to those who are currently underrepresented.

STEM educators can build a more comfortable classroom culture by avoiding the harsh system of grading that was found to contribute to competitive and stressful atmosphere in introductory STEM courses. Researchers recommend that STEM programs adopt comprehensive assessment strategies aimed at building confidence among all STEM undergraduates, particularly ALANA students (Palmer et al., 2011). A change in the grading system may also encourage self-confidence among women in STEM, which is critical for women’s persistence decisions (Hyde & Gess-Newsome, 2000). A well-planned system of assessment can help all students to feel more comfortable and confident in introductory STEM courses, improving STEM persistence overall and especially for White women and ALANA students.

Another way to establish a more comfortable classroom culture is for STEM instructors to show support and care for all of their students. In this sample, instructors who learned their students' names, handed out candy, and stayed after class to answer questions were viewed as more approachable than other STEM instructors. As found in this study, these "small acts" of kindness and care can have an impact on the classroom culture and may more encourage students to choose and persist in STEM majors.

Finally, STEM educators should adopt a "no stupid questions" policy in all introductory STEM classrooms; that is, no student should ever be harassed or called out for asking a question. The instructors in this sample who allowed for safe, open discussion of content saw students who were more comfortable and participatory in the classroom, leading to increased student learning, engagement, and persistence in STEM. Oppositely, the instructors who poked fun at students for asking simple questions caused students to feel anxious and less likely to participate. The age-old adage "there is no such thing as a stupid question" suggests that all questions should be viewed as requests for further knowledge, particularly among STEM undergraduates.

Departmental and institutional administrators also have a role to play in the improvement of STEM classroom culture and increased persistence for STEM undergraduates. Both students and instructors reported problems related to large lecture-style courses, including worry about talking in large groups and limited interaction.

Smaller class sizes, or smaller groups of learners in a large class, serve to foster a culture of comfort. Research suggests that this department-level change may be particularly influential in matching the preferences of women (Persaud et al., 2006).

Another way for STEM departments to match the preferences of students is to schedule classes later in the day, which participants in this study suggested as leading to more student energy and engagement. Recent research indicates that adolescents (ages 13 to 18) are most likely to meet or exceed the recommended amount of sleep when school starts after 8:00 am (Paksarian, Rudolph, Jian-Ping He, & Merikangas, 2015). While research on college students and later start times is more limited, some institutions have moved class times later in the morning to promote sleep and academic success ("Start Times, Course Availability, and Sleep," 2004). Both students and instructors could benefit from later class start times, well-rested students, and increased engagement in the STEM classroom.

Further development of campus resources and supports will allow STEM students to feel less stressed about grades and competition. Experts recommend the establishment of study groups, tutorial centers, faculty feedback systems, and improved student orientation programs (Hrabowski III & Maton, 2009). ALANA students benefit from proactive student support services and creative experiences to persist and succeed in STEM majors (Palmer et al., 2011), but the many generic "minority programs" that do not address the specific needs of individual racial and ethnic groups are unsuccessful (Seymour & Hewitt, 1997). For decades, education researchers have suggested multicultural and bilingual education to support ALANA students (Malcom et al., 1976).

Limitations

There are a number of limitations and challenges associated with the author's implementation of this study that may affect the validity of conclusions drawn from the results. First, although the author joined the TAL-R study at its start in 2012, and has followed the research team throughout the duration of the study, it is important to note that the bulk of study's methods and data sources were determined prior to the author's involvement.

For example, the use of interview data from individual instructors and student focus-groups allowed for rich, thorough description from the viewpoints of actors in the classroom field. Self-reports, however, are not as reliable as other types of data when attempting to determine causal pathways. Scholars Cook and Campbell (1979) pointed out that research participants tend to report what they believe the researcher wants to hear or answer in a way that reflects positively on themselves. With these issues in mind, it is possible that the data described in this study may be biased toward the research team's viewpoints as well as toward the participants' own idealistic beliefs about STEM persistence. Although this study certainly describes the classroom culture in the opinion of the research participants, it does not objectively describe or compare this culture to others from an outsiders' or statistical perspective. That is, the classroom culture was not measured or quantified by an impartial observer; the data were relayed from actors in the classroom field to the researchers asking questions from a protocol.

One methodological problem arose during data analysis. Upon completion of the coding process, the frequencies of co-occurring themes (i.e., similarity matrices) were fed into the UCINET (Borgatti, Everett, & Freeman, 2002) multidimensional scaling (MDS) function. MDS is mathematical procedure that organizes data by representing the similarities of objects spatially, as though they were locations on a map (Schiffman, Reynolds, & Young, 1981). More specifically, MDS finds a representation of *N* pairs of items in the fewest possible dimensions in space so that the distances between points best match the original proximities (R. A. Johnson & Wichern, 2007). Once an MDS plot is created, a measure of "stress" is used to measure the amount of distortion between the actual values in a similarity matrix and the visual representation of the values in the MDS plot (Namey, Guest, Thairu, & Johnson, 2008). In this study, visual depictions of coded data were meant to inform analysis of causal pathways by evaluating the relative distances between antecedent factors, classroom culture descriptors, and student outcomes.

Ultimately, MDS visualization methods were found to be inappropriate for the coded data. The MDS plots that were produced to visualize co-occurrences with three dimensions resulted in stress values much greater than the 0.1 a cutoff value (Kruskal, 1964). This high stress value indicates a poor fit between the actual values and their representation in the plot. With the addition of more dimensions, the MDS plot approached an appropriate stress level to indicate an accurate fit, but a graph of more than two dimensions is too complex to aid in the analysis of co-occurrences of themes. In addition, the complexity of the data, including the number of overlapping themes that included multiple causal pathways in the same paragraph or the same sentence resulted in unreliable co-occurrences data for this type of analysis. Thus, causal pathways were not explored via visualization techniques but rather through an understanding of co-occurring themes in the data set as well as via rich descriptive analysis of transcripts.

Scholars propose criteria such as credibility, dependability, and transferability to evaluate the trustworthiness of qualitative research (Guba & Lincoln, 2000; Lincoln & Guba, 1985). Credibility refers to whether the participants' perceptions match up with the researcher's portrayal of them (Bloomberg & Volpe, 2015, p. 162). To corroborate causal pathways and improve this study's credibility, it is best to collect and analyze both qualitative and quantitative data. For example, the TAL-R study collected data using the TDOP (Hora & Ferrare, 2014) as an observation protocol to measure the teaching methods, pedagogical moves, instructor/student interactions, cognitive demand, instructional technology, and student engagement in the classroom. This tool measures some of the themes that participants discussed in the interviews (e.g., lecture-style teaching, low student engagement), and may be used to further emphasize the specific antecedents that lead toward certain classroom culture descriptors.

Returning to institutions previously researched in the TAL-1 study, which are all Predominantly White Institutions (PWIs), severely limited the number of ALANA students in the sample. The possibility of adding Historically Black Colleges and Universities (HBCUs) and other, more diverse institutions was discussed during the early stages of the TAL-R project, but this part of the project was not realized. Ultimately, the decision to focus on two large, research-focused PWIs allowed for the evaluation of institutions that confer the largest percentage of STEM degrees in the U.S. higher education system (American Institutes for Research, 2013). However, this choice is also a delimitation for the study's transferability, or generalizability. While some findings may be generalizable to introductory STEM courses at other types of institutions, many are likely unique to this setting and population.

Directions for Future Research

In recent years, the TAL-R study team has released a number of publications that suggest that this work needs to continue. For example, the author's colleagues Ferrare and Lee (2014) confirmed with national data that researchers do need to continue to talk about leaving, because disproportional switching is still a major educational and social equity problem. Qualitative analysis (e.g., Benbow & Vivyan, 2016) is a rich, descriptive way for researchers to better understand why this problem still exists. Continued qualitative analysis of introductory STEM courses will both inform and support further quantitative research.

This study revealed a number of themes that relate to the present state of classroom culture in introductory STEM courses, how it is cultivated, and its impact on student outcomes. More specifically, this study supports the literature and also highlights some specific, nuanced antecedent factor themes that have not been discussed in previous research (e.g., no stupid questions, support and care). Future research studies in this area might focus on measuring and quantifying these factors to determine how they are correlated with student outcomes. For example, an intervention study on the cultivation of a safe space for open inquiry in introductory STEM classrooms may further support the idea that a "no stupid questions" policy is an antecedent for positive, comfortable classroom culture as well as student persistence in STEM.

To directly address the problem of underrepresentation in STEM, a more intentional focus on White women and ALANA students is imperative. Given more voice, these individuals might be able to tell their stories via individual and/or focus-group interviews centered on issues of underrepresentation and bias. Future research studies should focus more closely on the experiences of these underrepresented students rather than the oft-studied broader population of students in STEM introductory courses. This necessarily requires more purposeful sampling of White women and ALANA students.

Although it is impossible to conduct a randomized controlled trial where social identities are randomly assigned to participants, it is possible to intervene with certain antecedents such as students' preparation or instructors' teaching methods. A greater number of studies that evaluate the effects of these interventions can contribute to the research base pointing to positive changes in STEM education. Again, the inclusion of White women and ALANA students as the population of interest is necessary to allow for disaggregation of data by gender and race/ethnicity so that differential effects of these antecedent factors can be further evaluated.

In addition to conducting more controlled studies, STEM researchers should report results in the context of social identities that we know are related to STEM classroom culture and persistence—gender, race/ethnicity, socioeconomic status, etc. Beyond the social identity factors addressed in this study, a number of other identities—including (dis)ability, gender identity, sexual orientation, etc.—could also provide critical information about which students are staying and which are leaving the competitive culture of STEM introductory courses.

Conclusion

The present study delineated number of factors and causal pathways that influence classroom culture and, ultimately, persistence outcomes for students in STEM. The decision to persist in or switch away from a STEM major follows a complex path that is heavily influenced by the classroom culture of the first few courses that students encounter in their undergraduate journey. The lack of equity among undergraduate STEM majors should point researchers toward continuing to solve the mystery of how to create more comfortable and welcoming environment in these critical courses.

This study provides a framework of factors for educators to address and for researchers to explore. Moving forward, the elements unveiled here will allow for more focused studies on the improvement of classroom culture in introductory STEM courses. This research also points to critical intervention points that may allow STEM educators to promote equity in STEM education and careers.

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Appendix A: Faculty Member Participant Informed Consent Form

Talking about Leaving Revisited:
Exploring Current Patterns of Persistence in the Sciences
Principal Investigators:
Anne-Barrie Hunter, University of Colorado, Boulder
Mark Connolly, University of Wisconsin-Madison

FACULTY MEMBER PARTICIPANT INFORMED CONSENT FORM

Please read the following material that explains this research study. Signing this form will indicate that you have been informed about the study and that you want to participate. We want you to understand what you are being asked to do and what risks and benefits—if any—are associated with the study. This should help you decide whether or not you want to participate in the study.

Your participation in this research study is voluntary. You are being asked to take part in a research project conducted by Anne-Barrie Hunter, a researcher in the University of Colorado at Boulder's Center to Advance Research and Teaching in the Social Sciences (CARTSS), Ethnography and Evaluation Research, 580 UCB, Boulder, CO 80309-0580 and Mark Connolly, a researcher at the University of Wisconsin-Madison, Wisconsin Center for Education Research, 1025 West Johnson Street, Suite 785 Madison, Wisconsin 53706. Anne-Barrie Hunter can be reached at 303-735-0887 (office phone), abhumter@colorado.edu (email) or 303-492-2154 (fax). Mark Connolly can be reached at 608-263-4233 (office phone), mrconnolly@wisc.edu (email), or 608-263-6448 (fax).

Purpose and Background:
The purpose of this research project is to learn about why undergraduate students continue or switch out of science, technology, engineering or mathematics (STEM) majors: about 50% of all students who enter college intending to major in a STEM discipline leave within the first two years. You are being asked to participate in a focus group interview because you are enrolled in a foundational STEM course commonly taken by STEM majors, or those interested in majoring in

a STEM field, and we want to explore your classroom experience and how this may influence your decision to stay in or leave from a STEM major. As part of this study, over 25,000 student transcripts will be analyzed, 4,200 students will be surveyed, and 850 students and 75 faculty members across seven institutions will be interviewed. This request for an interview is part of a national research study called "Talking about Leaving Revisited: Exploring Current Patterns of Persistence in the Sciences" and is supported by grants from the National Science Foundation and the Alfred P. Sloan Foundation. Again, participation in this study is voluntary.

Procedures:
If you agree to take part in this study, you will be asked to participate in an individual interview to talk about your thoughts, experiences, and perspective about the class. The interview should take about an hour, depending on how much you have to share. The interview will be conducted in-person at a time that is convenient to you. With your written permission, we will digitally record the interview to ensure accuracy in analysis. Upon completion of the project, all interview recordings are erased or otherwise destroyed. If you do not wish to be digitally recorded, do not participate in this study.

In addition to participating in an interview, we are asking your consent to observe your class two times using the Teaching Dimension Observation Protocol, which captures multiple facets of teaching (pedagogical strategies, levels of student cognitive engagement, and instructional methods and technologies).

As well, if you agree to be interviewed and for your class to be observed twice, we are also asking that you agree to send two emails to students in the class containing (1) a link to participate in a voluntary focus group and (2) a link to the Student Assessment of their Learning Gains (SALG) survey, which they will fill out online outside of class. The SALG instrument is an end-of-course assessment used by hundreds of faculty nationwide that asks students to rate their learning on aspects of the course and what aspects of the course supported their learning (see http://www.salgsite.org).

Please know that data collected from the interview, the classroom observation using the TDOP, the focus group, and the SALG survey are for research purposes only and will not be used for evaluative purposes.

Risks and Discomforts:
The only foreseeable risk to you if you take part in this study is that some of the questions may cause you to feel uncomfortable.

Benefits:
There are no obvious direct personal benefits to participating in this interview. A possible benefit to you may be that, in the course of the interview, you may gain greater insight into your academic experiences and choices, but this cannot be guaranteed. The information gained from the study will be used to inform university administrators and instructors on practices that help students remain in their STEM major.

Source of Funding:
Funding for this study is being provided by grants from the National Science Foundation (NSF) and the Alfred P. Sloan Foundation. This study is being funded by a federal agency (the NSF) that requires that data be collected in a form that may be analyzed for differences between men and women and races or ethnic groups.

Cost to Participant:
There are no costs involved in participating in the study.

Subject Payment:

You will not be paid for participation in this study.

Study Withdrawal:
You have the right to withdraw your consent or stop participating at any time. You have the right to refuse to answer any question(s) or participate in any procedure for any reason.

Confidentiality:
These are some reasons that we may need to share the information you give us with others:

- If it is required by law.
- If we think you or someone else could be harmed.
- Sponsors, government agencies or research staff sometimes look at forms like this and other study records. They do this to make sure the research is done safely and legally. Organizations that may look at study records include:
    i. Office for Human Research Protections or other federal, state, or international regulatory agencies
    ii. The University of Colorado Boulder Institutional Review Board
    iii. The sponsor or agency supporting the study: in this case, the National Science Foundation and the Alfred P. Sloan Foundation.

The Interview: We will make every effort to maintain the privacy of your data. Tape recordings of interviews are transcribed verbatim for analysis at the Wisconsin Center for Education Research, University of Wisconsin-Madison. Upon completion of the project, all interview recordings are erased or otherwise destroyed. Digitally recorded interviews for this study will be erased by January 31, 2022. All interview data is kept in a secure location. Code names are given to digital recordings and other information connected to you and your participation to aide in maintaining confidentiality. All results from this project will be reported in aggregate form, and any quotations cited will be used only so long as the participants remain anonymous.

Invitation for Questions:
If you have questions about this study, you should ask the researcher before you sign this consent form (see contact information on page 1).

If you have questions about your rights as a research study participant, you can call the Institutional Review Board (IRB). The IRB is independent from the research team. You can contact the IRB if you have concerns or complaints that you do not want to talk to the study team about. The IRB phone number is (303) 735-3702.

Authorization:
I have read this paper about the study or it was read to me. I know the possible risks and benefits. I know that taking part in this study is voluntary. I choose to be in this study. I know that I can withdraw at any time. I have received, on the date signed, a copy of this document containing 3 pages.

Please select one of the following choices to indicate your level of desired participation in the study:

☐ *I consent to participate in all aspects of this study:* I agree to participate in an individual interview and understand that this interview will be digitally recorded; I also agree to have my class observed two times using the TDOP; and I also agree to send two emails to students in the class containing the link to the focus group invitation and the SALG survey at the end of the semester. ***I understand that the that data collected from the interview, the classroom***

observation using the TDOP, and the SALG survey are for research purposes only and will not be used for evaluative purposes.

☐ *I consent to participate in some, but not all, aspects of this study* (cross out aspects you do NOT consent to): I agree to participate in an individual interview and understand that this interview will be digitally recorded; I also agree to have my class observed two times using the TDOP; and I also agree to send two emails to students in the class containing the link to the focus group invitation and the SALG survey at the end of the semester. ***I understand that that data collected from the interview, the classroom observation using the TDOP, and the SALG survey are for research purposes only and will not be used for evaluative purposes.***

Name of Participant (printed) ____

Signature of Participant ____________________________ Date ______________.

(Also initial all previous pages of the consent form.

Appendix B: Study Focus-Group Participant Informed Consent Form

Talking about Leaving Revisited:
Exploring Current Patterns of Persistence in the Sciences

Principal Investigators:
Anne-Barrie Hunter, University of Colorado, Boulder
Mark Connolly, University of Wisconsin-Madison

STUDENT FOCUS-GROUP PARTICIPANT INFORMED CONSENT FORM

Please read the following material that explains this research study. Signing this form will indicate that you have been informed about the study and that you want to participate. We want you to understand what you are being asked to do and what risks and benefits—if any—are associated with the study. This should help you decide whether or not you want to participate in the study.

Your participation in this research study is voluntary. You are being asked to take part in a research project conducted by Anne-Barrie Hunter, a researcher in the University of Colorado at Boulder's Center to Advance Research and Teaching in the Social Sciences (CARTSS), Ethnography and Evaluation Research, 580 UCB, Boulder, CO 80309-0580 and Mark Connolly, a researcher at the University of Wisconsin-Madison, Wisconsin Center for Education Research, 1025 West Johnson Street, Suite 785 Madison, Wisconsin 53706. Anne-Barrie Hunter can be reached at 303-735-0887 (office phone), abhumter@colorado.edu (email) or 303-492-2154 (fax). Mark Connolly can be reached at 608-263-4233 (office phone), mrconnolly@wisc.edu (email), or 608-263-6448 (fax).

Purpose and Background:
The purpose of this research project is to learn about why undergraduate students continue or switch out of science, technology, engineering or mathematics (STEM) majors: about 50% of all students who enter college intending to major in a STEM discipline leave within the first two years. You are being asked to participate in a focus group interview because you are enrolled in a foundational STEM course commonly taken by STEM majors, or those interested in majoring in a STEM field, and we want to explore your classroom experience and how this may influence your decision to stay in or leave from a STEM major. As part of this study, over 25,000 student transcripts will be analyzed, 4,200 students will be surveyed, and 850 students and 75 faculty members across seven institutions will be interviewed. This request for an interview is part of a national research study called "Talking about Leaving Revisited: Exploring Current Patterns of Persistence in the Sciences" and is supported by grants from the National Science Foundation and the Alfred P. Sloan Foundation. Again, participation in this study is voluntary.

Procedures:
If you agree to take part in this study, you will be asked to participate in a focus group interview with up to seven students who are enrolled in the same course to talk about your thoughts, experiences, and perspective about the class. The interview should take about 90 minutes, depending on how much the group has to share. The interview will be conducted in-person at a time that is convenient to you. With your written permission, we will digitally record the interview to ensure accuracy in analysis. Upon completion of the project, all interview recordings are erased or otherwise destroyed. If you do not wish to be digitally recorded, do not participate in this study.

Risks and Discomforts:
The only foreseeable risk to you if you take part in this study is that some of the questions may cause you to feel uncomfortable.

Benefits:
There are no obvious direct personal benefits to participating in this interview or providing your transcript. A possible benefit to you may be that, in the course of the interview, you may gain greater insight into your academic experiences and choices, but this cannot be guaranteed. The information gained from the study will be used to inform university administrators and instructors on practices that help students remain in their STEM major.

Source of Funding:
Funding for this study is being provided by grants from the National Science Foundation (NSF) and the Alfred P. Sloan Foundation. This study is being funded by a federal agency (the NSF) that requires that data be collected in a form that may be analyzed for differences between men and women and races or ethnic groups.

Cost to Participant:
There are no costs involved in participating in the study.

Subject Payment:
As a small thank you for your participation, we will offer you a choice of a $15 gift card for Starbucks coffee or iTunes music.

Study Withdrawal:
You have the right to withdraw your consent or stop participating at any time. You have the right to refuse to answer any question(s) or participate in any procedure for any reason.

Confidentiality:
These are some reasons that we may need to share the information you give us with others:

- If it is required by law.
- If we think you or someone else could be harmed.
- Sponsors, government agencies or research staff sometimes look at forms like this and other study records. They do this to make sure the research is done safely and legally. Organizations that may look at study records include:
    i. Office for Human Research Protections or other federal, state, or international regulatory agencies
    ii. The University of Colorado Boulder Institutional Review Board
    iii. The sponsor or agency supporting the study: in this case, the National Science Foundation and the Alfred P. Sloan Foundation.

The Interview: We will make every effort to maintain the privacy of your data. We cannot promise complete confidentiality or anonymity due to the possibility that, although we will ask participants not to disclose what is discussed outside of the focus group, participants may, nonetheless, disclose information outside of the focus group, thereby breaching confidentiality. Tape recordings of interviews are transcribed verbatim for analysis at the Wisconsin Center for Education Research, University of Wisconsin-Madison. Upon completion of the project, all interview recordings are erased or otherwise destroyed. Digitally recorded interviews for this study will be erased by January 31, 2022. All interview data is kept in a secure location. Code names are given to digital recordings and other information connected to you and your participation to aide in maintaining confidentiality.

All results from this project will be reported in aggregate form, and any quotations cited will be used only so long as the participants remain anonymous.

Invitation for Questions:
If you have questions about this study, you should ask the researcher before you sign this consent form (see contact information on page 1).

If you have questions about your rights as a research study participant, you can call the Institutional Review Board (IRB). The IRB is independent from the research team. You can contact the IRB if you have concerns or complaints that you do not want to talk to the study team about. The IRB phone number is (303) 735-3702.

Authorization:
I have read this paper about the study or it was read to me. I know the possible risks and benefits. I know that taking part in this study is voluntary. I choose to be in this study. I know that I can withdraw at any time. I have received, on the date signed, a copy of this document containing 3 pages.

Please select one of the following choices to indicate your level of desired participation in the study:

☐ *I consent to participate in all aspects of this study:* I agree to participate in a focus group interview and understand that this interview will be digitally recorded.

Name of Participant (printed) ____

Signature of Participant __________________________ Date _____________.

(Also initial all previous pages of the consent form.)

Appendix C: Faculty Member Individual Interview Protocol

Talking About Leaving Revisited
Instruction/Gateway Course Study Team
Joseph J. Ferrare, Ross Benbow, Mark Connolly, Erika Vivyan, and Anne-Barrie Hunter
For questions please contact: Joseph J. Ferrare (ferrare@wisc.edu)

Introduction: Can you please **briefly** tell me about your current position?

Teaching and learning:

I'd like to begin by talking about your approach to teaching and learning in this course. [Verify course] What are the most important things you want students to learn in [the course]? You can just list these things; I don't need you to explain what they mean.

Is there anything about the nature of [most important thing(s) mentioned] that suggests a specific approach or style of teaching?

What do you think is the best approach to introducing students to [most important thing(s)] in this course?

What role, if any, does the instructor play in this approach?

What is your view about how undergraduates come to understand and apply the [most important thing(s)] in this course?

How do you assess what students have learned in your class? Is your grading done on a curve?

Student interaction and advising:

How much—and what types of—interaction do you have with undergraduates outside of the classroom?

Do you play a role in advising your undergraduate students about academic issues?

Is mentoring undergraduates a part of your role?

- (Prompt for in what circumstances or at what educational stage in the major.)

Influences on teaching practices:

I'd like to ask you about some of the things that influence the way you teach this course. What things influence your selection, organization, and presentation of the course material?

- Follow-ups: How much flexibility do you have in this process? Is the syllabus fixed or can you make changes?
- Are your approaches influenced by collegial expectations? Departmental expectations?
- What about your time and other work commitments? Do those influence your approaches?
- Does the type of students in the course influence your approaches?

(If not discussed thus far) Does the culture of your discipline, department and/or institution influence what you teach and how you teach in this class?

Is there anything about your position as a [insert rank here (e.g., tenured professor, lecturer, etc.)] that influence what you teach and how you teach in this class?

Thinking in general, do you believe an instructor's rank or status—whether they are or are not on the tenure track, whether they run a lab, etc.—has any influence on their approaches to teaching?

Classroom culture:

Some people say that classrooms have a "culture." By that they are generally referring to the unstated (though sometimes explicitly held) norms that suggest how students are supposed to interact with each other and with the instructor, as well as the strategies that tend to lead to success or failure in the course.

Does this classroom have anything resembling a classroom culture? (if yes, follow up w/ bulleted items)

- What do you think creates this culture? How much of it has to do with the students, how much of it has to do with you, and how much of it has to with other things?
- Do you think the system of grading has any influence on this culture?
- Would you say there is a so-called "weed out" culture in this course?
- Does this culture influence the way you organize and deliver the course material?

  Do you think this culture influences student learning and motivation to learn the key concepts?

Professional development:

Have you participated in any teacher training or professional development related to teaching? If so, what types of training or development have you undertaken, when did you do this, and how did it come about?

- Did you learn about research that supports particular kinds of teaching practices?
    - How convincing did you find the evidence?
- Have you made any changes in how you teach based on what you learned?
- Have you encountered either supports or constraints from your department or institution to making changes to your teaching based upon what you learned?

[If they have not participated] Are teaching focused professional development options available to you? (Explore what these are?) If so, what has influenced your decision not to participate?

- Have any aspects of your position, department, or institution affected this decision?

Do you use any teaching practices that, in terms of effectiveness, you know to be supported by research? If so, what practices do you use?

- What influenced your decision to use this teaching practice?

(If they are working with TAs): Does your TA (or TAs) receive any training? Is this training adequate?

Student persistence:

As you know, part of this study is about student persistence in STEM fields. I'd like to finish with some of your ideas on this topic. In general, when a student completes an undergraduate degree in your field, what factors do you think contribute to this outcome? (Listen for the distribution of responsibility/causal attribution; probe as needed)

Conversely, when a student switches from your field to a non-STEM major, what do you see as contributing to this outcome? (Listen for any shift in distribution of responsibility/causal attribution)

[If not mentioned previously] As I am sure you are aware, there have been considerable efforts to make your discipline, and the sciences in general, more appealing to students of color and to women of all races and ethnicities. Do you think there are any particular challenges or opportunities for women and for students of color who are pursuing a degree in your field?

- Do you think any of these identities shape students' sense of belonging and/or their emerging identity as a scientist (or engineer, etc. depending on their major)?

What about financial concerns—such as the need to work or concerns over financial aid?

How much influence do you think instructors have over student persistence and field-switching?

Follow up questions (IF TIME)

1. Do you have any additional points you'd like to make about any of the questions I've asked?

2. Give some advice to this school, your department or faculty: What could they do if they wanted more people to graduate in a STEM major?

Do you use any indicators of mathematics readiness to guide student selection into your major or to predict their success in the major? If so, which ones?

Have you noticed any changes in the students majoring in your field over the past 10 to 15 years? (If changes have been observed) Have these changes influenced your teaching practices as a result?

Appendix D: Faculty Member Individual Interview Transcript Example

I: Interviewer

F: Faculty member

CLASSROOM CULTURE SEGMENT

I: Ok. So, I jumped quickly into classroom culture a little bit back but it sounded like there was more that you might wanna say about what might be the said and unsaid norms about the way the class works.

F: I want- the unsaid that I hope I communicate to them early on in the first few days of class and week is everybody- any question has value, everybody is, you know, important, we're learning together. That this is very much a together thing and it's not me telling you what to do but if you have something that you wanna add- I mean I just- I really want it to be, again, a facilitator in their learning. I want them to take responsibility for it though and I want them to blame me if they don't get something, you know? So I want them to understand that I'm expecting them to attend to their own learning. I know but-

I: But you'll meet them-

F: Yes but I'll help 'em anywhere, anytime they need help. They can come. We'll talk it through. I'll tell them how I would suggest them studying, you know, but I'm not just gonna give them an old exam and say, "Study this and learn this and know this."

I: How can you tell if a student's taking responsibility for his or her own learning?

F: There's sometimes a shift in the way that they interact in the classroom. Maybe they move forward more. Maybe the- I just see it in their eyes as they're engaging with me more. Some of that. They come to office hours or come- you know, make an appointment with me and talk about how something really worked and the- this exam versus the other exam and you know that they're feeling good about the grade that they're making or they're wanting to know what they can do better for the next exam. You know, [they're taking]-

I: [So they're looking] for feedback.

F: Yeah, they're all- they're looking for that feedback. I think those would be-

I: Good. Um. Obviously I'm working from a set protocol and you're giving me such great answers (0:30:05.5) ______ like ok I think she covered this, she covered this, she covered this. Um. But I- this is worth being explicit about and- but then how- so then how do you think then the culture you've just described about doing all you can to support their learning but clearly having expectations that they take responsibility for themselves, how do you think this culture then influences how and what they learn?

F: Ah. And that's a big key to your study. I mean that's- I think- hmm. I think any time you have positive reinforcement and you feel good about yourself and you feel good about your environment, you are open much more to effort in that environment and to working harder to please or to get to the goal. You want to do it more.

I: So increases motivation.

F: Yeah. I do. I think it does.

I: Try harder.

F: I think it also- if you- if you are in an environment where you know you're liked and you know it's not an adversarial sort of spirit around, then it releases you to maybe go further than you think you can. So you push.

PERSISTENCE SEGMENT

I: Um. We're at our- I think the last section which is- so this is about student persistence. So, as you know, part of the study's about what we call STEM persistence. So not whether or not students persist in college but whether or not they start in STEM fields and then they stay-

F: Absolutely.

I: -stick through that until graduation. So, let me start the conversation asking about that phenomenon in this way. So when a student completes an undergraduate degree say in ecology, I mean that's very specific but I might say biology in general, what factors do you think contribute to that successful outcome?

F: That's really good. Good, good, good question 'cause it's um- yeah. We need to chew on this a lot. I think one is um first few semester courses that they get pos-- that they feel positive about. Um obviously they make good grades. They- um, and feel that they can do the material um and-

I: Because the grades are-?

F: The grades drive-

I: -a reflection-

F: Yeah.

I: -indicator-

F: Of what- yeah- will happen when they take the MCAT or when- you know, or when they are- apply for graduate school or something and that- if they made bad grades and they're on their transcript, they're not gonna be looked at and not gonna be accepted. Um. So they know that the grades are pretty important to show up on the transcript for admissions. Um a second thing is- so- so that's sort of a thing that will cause people to- you know, if they're making consistent Cs and Ds and they just can't bring them up in chemistry, in organic, you know or something and- and they have to have that grade, then, "Ok. Maybe I'm not gonna go through this college to get to medical school. I'll go to another one that doesn't require organic." You know or something like that. Um. Or, "I need to just step back and do law." You know? So (BOTH LAUGH) that's true. I hear it- I hear it-

I: Or business.

F: Business. Yes. Lots of business. Um the other thing I think really is if you get those students engaged in some form of research or an internship or a mentorship in a lab where they're actually doing- practicing science and they are engaged in taking what they're- they've been learning and applying it in a very real world setting, the science that they're doing, that will- how can they leave? How can they leave really? You know, they're connected. They're needed. They're involved and they're making a difference. That's huge.

I: You know I'm curious that- so, in another part of my research life I study graduate students and the formation of doctorate students as future faculty and we all know how brutal life can be [in the lab]-

F: [The process].

I: -for graduate students. What is it that keeps it from having the same effect on [undergraduates]?

F: [That's so true]. Yeah. Yeah. Um. I think because as an undergraduate, this degree is sorta like the gateway to everything, to living, to life, and they know it and they come in either with that pressure from their above, from their parents, or from within themselves, wherever direction it's coming from that pressure is there and real and- and so, the students that we're getting these days, I think they know this is- this is kind of a do or die. Can't just fall back and something else.

I: So the stakes-

F: Yeah, [pretty high].

I: -[seem to be a lot higher] for them.

F: And they feel that. They come in and they talk and you can tell that they're- you know, there's a lot of angst in- in- [in their life or you know the]-

I: [Yeah there's not as much time and] space for-

F: No, [exploring. No].

I: -[wandering and wondering].

F: There's not. They come in and they- you know, there's not that 60s I guess and 70s you know let's just take every kind of-

I: Do your own thing, right.

F: Yeah do your own thing and pull it all together and something will- good will come out at the end with a degree. It's not there. It's-

I: Or that any kind of college degree is-

F: No.

I: -is a-

F: No. Yeah. For- and not just in sciences but it's not there anymore. I think all students have that and if they don't, they- they're- they leave. They quickly realize they don't fit in well to the culture of college, university.

I: And I- that's definitely what we're hearing in the interviews. Um. So, the- that's- that's a great answer to the question about so what contributes the successful outcomes. So conversely then when a student switches from the field to a non-STEM field, what do you see as the things that contribute to those?

F: Um one, they just- I mean in- in truth and honesty, they don't have the capacity to do the field that is required for science. Um they- they- it's just not there and that's not a bad thing 'cause they may have just as good a- you know, but it's just not there and maybe they were wanting to do this because they thought it was, you know, what their parents wanted or something but just something deep in them that's just not allowing that to happen, whether it's brain capacity or whether it's motivation or- or just desire of that field. Whatever it is, it's not there.

I: Do you think it might- has to do with like kind of intelligence? Like whether or not [so for example you know if]-

F: [Think that- oh yeah. Absolutely].

I: -somebody could really love um the life sciences but have a hard time thinking quantitatively or-

F: Yes. Yes, and you have to. You have to be able to do some of that to go forward and go on. So yes, I do. I do think that could be just- just a pure capacity is not- is not there. Um. Some, but I don't think that's a large number of people. I think they kinda self-weed before that maybe? Um. You know, know thyself sort of thing. I think that they have that ability. I don't think they're just wandering around. I think some um really love science and want to be in it and are just sort of swept away when the masses and aren't pulled out and nurtured and shown again that they have value and they're not just a number and that they can make a difference, and I think they feel that and some of those people that that affects the feelings affect them more deeply than others. Others can let that watch over them. Other- some people can really take that to heart and I think that they then- few failures that they might have- there's no support.

I: I mean, are you saying that uh for example that they don't feel like they belong or they don't feel connected or-?

F: I think all of that. Yeah. They don't have the connection to keep them going even through some failures or through some bad- you know, some bad-

I: Setbacks.

F: -setbacks they might have. They don't have that to pull them out of it and other that they don't feel that it matters. "Why should I put forth the effort when no one really cares if I- you know- pass this or fail this. It's not really"- and- and I- I don't know how much of that is there but I see some of that in talking to students.

I: Can you-

F: From other- and- and I'm not- I don't know how to say this. I've talked to students who've had bad experiences in science classes or STEM classes and then they come into biology and they're saying, "I've had- I- I'm liking this. I'm having fun." Just in the conversations that I've had with them, they're- that's some of the differences that I've been able to glean out of what they're feeling.

I: Right. So they're- it- in that case then is it that they seem to identify more with the life sciences as a kind of science or that there's-

F: Maybe-

I: -something about the way the life sciences are taught?

F: I think both of those things. Both of those things. That there's an identification that they have more- they feel more connected to the life sciences which I can understand that definitely but they also are made to feel more involved and accepted in the- by that faculty, by the course.

I: Ok. And then by the opportunities that are made available to them like undergraduate research.

F: Yes. All of those sort of things. Yeah. I do.

I: So you must- you- in that job that you no longer have as the director-

F: Yeah, yeah.

I: -when you said [you spent a lot of time advising students]-

F: [Assistant director. Yes]. Yeah I did. Yeah, [a lot].

I: [You must've heard] lots of [stories].

F: [Exactly] and I'm- I'm talking through those experiences that I had. Yes.

I: So sometimes it was that the class-

F: Oh my goodness the guy-

I: -the early experiences.

F: "Oh he hates us. He- he all- he- he"- you know, this would be- you know, "He hates us. He just wants us to fail. He can't wait to give us an exam that we, you know, have an average of 20 on. You know, and- and he loves that and he"-

I: Some kind of perverse delight in-

F: Yeah. Yeah this is the perception they have and that, "He is um you know looking for ways to make us fail 'cause he doesn't like us and want us to pass and um he wouldn't help me if I went in to ask him to help. You know or- or she, you know, she- she wouldn't answer my question ever. I won't go into her office and ask her questions 'cause she'll make- she'll put me down. She'll make me feel um you know dumb and um she might even point it out in class." You know?

I: I imagine you know some of the faculty the students were talking about.

F: Yeah.

I: So did you feel like there was a lot of validity to these-?

F: Sometimes. Sometimes.

I: Ok and sometimes not.

F: Sometimes not, but sometimes there was. I could see that. It was coming from some of the more traditional um faculty.

I: Faculty. Um.

F: I've never heard that too much from the new- newer faculty.

I: And when you say newer faculty, are you referring to the- like the lecturers?

F: Lectures and re-- and some research faculty that would be put into some of the introductory majors courses for chemistry or math or some of the others in addition to biology but that would have a better grip on things with the students, not treat them severely.

I: Um. And that sometimes they felt like they just didn't fit. Like that- that it did- they might come to you saying, "I just feel like it doesn't matter to anybody here if I should survive or fail in this class."

F: Right. "I'm not supported and not- you know, and I'm not going to be and there's no way I can pass or go to- if- you know. Or you know or- anything- there's just no way I can 'cause it just- they don't care."

I: Do you- what kind of help if any do you think students need with interpreting early grades as to, you know, signals of their [ability to success]?

F: [Yeah, that's probably]- probably something that- that could be done better, because there's not a lot of that. There's the midterm report that goes out that tells them what their grade is at that point and that's sort of a- an indicator to help them know whether to get on it or that they're in a good spot but there's really- there's not a lot and especially in fields that um- like chemistry where you never know 'til the very end what your grade is even gonna be because a 50 is an A, can be, and a 20 could be a B. I mean you know [it just depends]-

I: [But you just don't] know.

F: You don't know and so you see these horrible grades and I totally don't understand this. I don't understand it. It's been explained to me that it's just how chemistry does and the American Chemical Society, this is their way. I don't get it. I don't get it and then you're like- students come to me and I'm like, I'm sorry. I'm a biology and we just don't even- don't even go in that field. I can't even understand it. It does not make sense to me to treat the student like that or have that be where a student's coming from but-

I: Right. And that it sounds like it's sanctioned by the disciplinary-

F: Yes, it is.

I: -organization. Um. So before I move on, 'cause I'm gonna ask you about students of color and women in STEM, any other thoughts about the reasons that- whatever it might be, whether it's the students give or the other kinds of influence do you think that might lead um students to say, "This isn't for me."

F: I hope that in our very, very diverse culture here at the university and that we um we celebrate that and it is not like a- we don't like look at it like, "Ooh wow. You know, that's so different." It's just that's how it should be. That- that our women and um uh people of color, African Americans and Hispanics and Native Americans and any other minority group, do not feel hindered and I hope that that's the message that they're getting 'cause that's certainly what we're trying to- to send is that there's no- it doesn't matter. You know, you're um- we have special scholarships, internships, positions, and things for people of color and especially for women of color um and they are- and like for engineering and you know for other STEM fields there are very key thing that are just for that group of people so that there's encouragement there as well.

I: Ok. 'Cause it's primarily the reason you see for it is that it's-

F: Yes. Yes. And there is some- I don't know. I- I know that within um standardized tests and grading scales and rubrics and things that there is a lower um sort of level that sometimes because of culture or other- whatever that might be that African Americans will score lower and that um that is taken into consideration.

I: Ok. Sometimes [it's referred to as an]-

F: [For decisions].

I: -achievement gap.

F: Is that what it is? Ok. I didn't know what to call it but I know that that is definitely taken into consideration.

I: Um. And-

F: They're not held the same.

I: Well the question here too is sort of- talks about students of color and women but I mean I'd like to split them out if I could so especially given the life science in the fact that compared with the other sciences-

F: Many more women and color.

I: So do you think there are particular challenges or opportunities for women who are pursuing a degree in this field?

F: I- for- for the- the natural sciences, life sciences, I don't know that it's so um bad anymore. It- it seem- I mean there's more graduates that have life sciences degrees that are women.

I: Ok. And that's at the undergraduate level.

F: Undergraduate level and [graduate].

I: [How- how high]? Graduate students.

F: Graduate students too.

I: And then faculty participation.

F: No.

I: Representa-- ok so somewhere-

F: There's a- there's a disconnect between the graduates and the- for, you know, so many, so many reasons that- but yes.

I: Ok. [So the faculty level you- not as quite]-

F: [You don't see that in the- it's working] to be reflected in the faculty more and there's conscious effort by the school, by the university to do that.

I: Ok. Um. How 'bout students of color in terms of the opportunities and challenges you think they face as um life science majors?

F: Yes. I think opportunities are good if they grab 'em in that there are internships and special scholarships and things that seek them out very specifically and that want to include them if they will apply and, you know, be comparable in their abilities. Um. Yeah, I've- I see we have um- oh goodness I can't think of any of the names of them but they are very specifically named fellowships and scholarships and internships that were- that are just for our people of color and women. I mean, in particular. So that is good. I understand that there is maybe some just sort of inherent block for women of color in advancing. They like will settle for nursing rather than going into being a doctor, a physician. Or they'll say, "Well I can always teach." And not- not saying that's bad, but if that's for them not their ultimate goal, then-

I: If that's a kind of settling.

F: Yeah if that is the- I do see that and I also see that happening- they're referring back to that sort of um fallback more when they have their setbacks or their failures rather than pushing through them. I think that- I don't have a- say that better but that's- I- I've seen that.

I: So far then as we've been talking about um women and students of color, do you think that any of these identities um shape students' sense of belonging or an emerging identity as a scientist or as an engineer?

F: I think they may come in with those. I hope we break them and help them form a more healthy scientific perspective of who they can be as a scientist and not see themselves as a scientist of color or a scien-- a woman scientist but as a scientist in general. I hope that we can do that, but I think some of them come in with those already set.

I: Um. And again drawing on your conversations with so many students, do- how- what did you hear when you had this about um the way in which financial concern shaped decisions either do pursue a major or to not switch because it would cost me more time?

F: Oh wow. Yeah. Well, pursuing a major, I'm sad to say that a whole lot of people come in, you know, "I'm gonna be a doctor because I wanna drive a Ferrari." You know? And ooh, in advising and stuff you hear that and I was like, "Ay ay ay. I hope you don't. I hope you switch out."

I: Become a mechanic.

F: Yeah. Something. Something. That's not why I want to go to you as my doctor 'cause you just want the money. So, there's that. There's definitely that, [the perception]-

I: [So the status].

F: The status and money and you know prestige of you know position that they'll get. Um. For those that might- what was it? Leaving the field or-?

I: Yeah. In other words to what extent financial concerns [drive decisions]?

F: [Financial concerns, yes. Ok]. Leaving can just be because they leave the university all together because they're working and they're trying to support a family or they're supporting completely themselves and just they have to work and their job is not flexible or helpful. So they would leave for that reason. Sometimes they come back later in a post-bac or come back, you know- they finish a degree that isn't as demanding, isn't as time consuming, doesn't have labs, doesn't have you know all the things 'cause science degree next to I'm sorry a home economics degree or something like that or you know or I don't know something without the labs and the time, extra stuff that you have to put in, you know, people have talked about their roommate is like you know out partying and I'm studying for my chem. test. You know? So there is a definite difference in that and so- so people just don't have that time to put in. They change but then they'll still wanna go to med school and they'll come back and do a post-bac and try to do it that way. They'll work around that.

I: How do you think the issue that you just mentioned, the amount of time that certain majors take, affects students who have to work to pay for school?

F: I think it affects. I definitely do. I think though, you know, sometimes life sucks on- you know what I mean? Honestly. It does and there's nothing, you know, so you decide, "I'm gonna work through this. I'm gonna grow over it. You know, I'm gonna go beyond that and just make that help me be a stronger person." Or, "This is too much and I have to let that dream go or you know change that," and that's just a- that's an internal thing. I don't know that we-

I: But it sounds like you- it wouldn't surprise you that students would say, you know, "My choice of a major may have been shaped by the fact that the only way I can stay in school is if I can work to"-

F: Yes. No, I see and I've heard that many times. Yes.

I: Um. Last question. How much influence do the instructors have over students' persistence in field switching?

F: That's a- such a good ques-- 'cause it's two pronged 'cause I could answer a lot and I can say none. You know because it's all from within the stu-- so you get some students and those are rare students, those are students maybe in the honors program or you know in the more accelerated type of programs that are just gonna drive themselves. It doesn't care. You could be spitting on them all day long and they're still gonna go for it and they're just gonna do it no matter what and they're gonna find the opportunities and they're gonna go for it and those are the amazing students and that doesn't matter. Instructor doesn't matter. I think beyond- despite- they will succeed and excel. But the majority of students are not like that and so there are many students who, especially coming in as freshmen, man, their psyche is still tender and they can be made or broken by some of their experiences with their instructors. Don't want that to be the case but I've talked to many that that has been.

I: Ok. So it's not just the class but it's sort of- so that personal-

F: I think so. I really do. I do. I think at some level there's a lot of that on the- you know, the formation of these decisions early on.

I: Ok. I'm ten minutes over. I'm so sorry.

F: Oh, that's ok. That's alright. No problem.

I: And I've got- I'm not gonna ask any more questions. It's like if you- if there's time but um, wow.

F: I don't- I don't mind. I have time. If you need time but it- you might have to go somewhere else so-

I: I do but-

F: 'Cause I have 'til 1:30.

I: -this has been incredibly rich. I mean this is wonderful because especially given your position as somebody who um clearly clears about her teaching and sort of you've gotta put a lot of thought into it but then given that- your role with- at the undergraduate biological-

F: Yes, the program. Right.

I: The program that you for a long time it sounds like saw another side of student-

F: I did.

I: -the student experience.

F: I really did. I did. I definitely did and a lot of that helped me as I was crafting and decided to teach and how I wanted to approach students. I mean some people say, you know, "You're like a mother to me." Well, is that so bad? You know do I need to come across rigid and scientific and, you know, you just- you know? I don't know. If that can help them, I'll do it. I mean that's my perspective. Whether that- lot of people probably don't- do not feel the same way as that but that is my personal perspective on that.

Appendix E: Student Focus-Group Interview Protocol

Talking About Leaving Revisited
Instruction/Gateway Course Study Team
Joseph J. Ferrare, Ross Benbow, Mark Connolly, Erika Vivyan, and Anne-Barrie Hunter
For questions please contact: Joseph J. Ferrare (ferrare@wisc.edu)

Introduction: Briefly explain TALR and what role the focus groups play in that process.

Can you please briefly tell me about your current major or intended major?

<u>Views of teaching and learning in relation to the course:</u>

I'd like to begin by talking about [name course]. My understanding is that you cover a number of important things. What do you think is/are the most important things to learn from this course?

- What do you think is the best way to really understand these things?
- How much depends on what the instructor does, and how much depends on what you do?

If you could choose how these important things were taught, what would you choose? Are the [important things] easier to understand if taught in a particular way?

- Do you think there is anything about the nature of these [important things] that lend themselves to a specific style of teaching, or are these things unrelated?

<u>Experience of the curriculum and pedagogy:</u>

Let's talk about how the course is taught by the instructor. What are some of the things that your instructor does that help to facilitate your learning?

- What about the way the course material is organized?
- What about the teaching methods your instructor uses?
- I noticed that your instructor did/used [fill in a specific teaching method from the observation] during the class I attended. In what way does this help or hinder your learning of the material?

<u>Outside activities:</u>

Aside from studying for exams and completing assignments, is there anything you typically do outside of class to better understand the course material—either in preparing to attend a class or in following up on what was covered? [Probe for using tutors, math centers, etc.]

- Do considerations and/or expectations of your classmates or instructor influence what you do outside of class?
- Other considerations? Work? Time?

<u>Advising:</u>

How much—and what types of—interaction do you have with the instructor (of this course) outside of the classroom?

- How about the TAs (if any)?
- How much, if any, help do you receive from your instructor outside of class? How about the TAs (if any)?
- Does this help your learning of the [important things] in this course? How?
- Does the help you get from your instructor and TA (if any) influence your motivation to pursue a degree in your chosen/interested field or switch to another field of study?
- Do you spend time with classmates or friends studying for or discussing this course outside of class? Do you ever get together to help each other with the course work or prepare for tests?

<u>Classroom culture:</u>

Some people say that classrooms have a "culture." By that they are generally referring to the unstated (though sometimes explicitly held) norms that suggest how students are supposed to interact with each other and with the instructor, as well as the strategies that tend to lead to success or failure in the course. Does this classroom have anything resembling a classroom culture? (if yes, follow up with bulleted items)

- What do you think creates this culture? How much of it has to do with the students, how much of it has to do with the instructor, and how much of it has to with other things?
- Can you point out specific things that have happened in this course that you identify as contributing to or indicative of this culture?
- Is there anything from [the observed] class?
- Does the grading system in this course contribute to this culture?
- Does this culture affect your learning of—or interest in—the course material?
- Does this culture impact your motivation to pursue a degree in this field of switch to another field of study?
    - What about your sense of belonging in this major?
    - Do you feel like this course is meant to "weed out" certain students?
    - Overall, have your experiences in this course, thus far, made it more likely or less likely that you will stick with your plans to complete a major in this field? Or has it made no difference?

<u>Student persistence:</u>

Have you experienced aspects of the culture we have been discussing in other classes in your field? Does this influence your thinking about whether you want to stay in this field or do something else?

What other things influence whether or not you will decide to stay in your chosen/intended major or move into something else?

I'm going to switch gears a little bit here. Do you think that, based on your own experience or that of your friends, economic circumstances such as financial aid, the need to work, and career prospects affect persistence decisions in your chosen/intended fields?

Do you think issues related to race, ethnicity, or gender present any special challenges or opportunities to pursuing a degree in your chosen/intended field?

- (If no): How about from the experiences of your friends or classmates?
- (If yes): Is there anything about the culture we have been discussing that influences these challenges or opportunities?
- Do you think these racial and/or gender identities shape your sense of belonging and/or your identity as a scientist (or engineer, etc. depending on major)?
    - How about that of your friends or classmates?

Follow up questions (IF TIME)

Do you have any additional points you'd like to make about any of the questions I've asked?

Give some advice to this school, your department or faculty: What could they do if they wanted more people to graduate in a STEM major?"

Appendix F: Student Focus-Group Interview Transcript Example

I: Interviewer

Name: Student

CLASSROOM CULTURE SEGMENT

I: Which is fine! (LAUGHTER) Um, thank you guys, for answering these questions for me. The next questions I have are about, um, how can I explain these. Some people say that each classroom has a culture, um, hear me out on this. By culture, by classroom culture, a lot of folks are referring to basically um, stated and unstated norms in the classroom. Um, about how students should interact with one another, how they should interact with the instructor, um, strategies that students should use to succeed in the class, or strategies that students use--or don't use--that cause them to fail in the class. Um, these things can be, like I said, stated or not stated, or you never talk about them, but some people would say they are still part of what make each classroom individual or different. Do you guys think that the classroom that we're talking about now, principles of biology 2, has a culture? And if you think it does, how would you describe it to me?

Sophia: This is Sophia. I think it does in a way; it's kind of subdued I guess. Like everyone was saying before, Dr. X really tries to engage the students, and ask questions and so, I think that sort of the dynamics of the classroom is people answering questions, um, but overall its—there are, I don't know, I wanna say like maybe ten people that like consistently answer the questions? And most other people will sit there--and I'm guilty. I will a lot of the times know the answer but I'm not 100 percent sure, so I don't wanna raise my hand, and it's just like back to middle school. But I think overall, it's like a mix, but I just feel like, I don't even know if this is answering it correctly, but I guess, in a way that's sort of like part of the culture, that there's a small group of people who are like, really interactive in class, but then like on the whole there are a lot of other people that just stay quiet. But she tries to engage everyone, so.

Talia: Um, this is Talia. I think um, I think like the personality of the professor kind of sets the mood of the class or like the culture. This class is actually like an outlier for sciences I think. Because, as mentioned before, like, Professor X is really enthusiastic and, um, just like a really nice person, and obviously she's really easy to reach out to, and so are her other TA's. But, I know for a lot of other science classes, the professors aren't like that at all. Because, I don't know where this is from, but I've heard X has like, on a list, it was like ranked twelve for worst college professors in the nation, because our school is a research facility, and a lot of our science professors are here for research and teach on the side. So, teaching us isn't like their main priority. And I don't wanna say they don't care, but they don't make it their mission to teach us. But I feel like X really does, and I feel like it makes her class more personable, and like, just, like I look forward to going to it.

Alice: This is Alice. Um, I sort of agree with Talia, but most of the teacher's I've had um, so far have been really nice and kind. Especially like, I think, if they're doing research, they will enjoy teaching other people about the topic they're interested in. So, like for my chemistry class, my professor, he's actually--he's done researching, so I guess he really loves teaching the students about it. I don't know if Dr. X's also doing research still, but she really enjoys teaching the class. So that it creates sort of a friendly atmosphere that you can ask any question and she'll be glad to answer it. So I feel like that's where the culture of the classroom as well.

I: Do I hear you saying it's kind of like a...people feel more open?

Alice: In her class, yes.

I: Like less...

Alice: I guess it also depends on what day it is. If it's like Monday morning, I'm pretty sure a lot of people are still half asleep, so they won't really answer.

I: What do you think, Igor?

Igor: I agree 100 percent with Talia. Everything she stated. She nailed it on the head, how I feel about science professors in general, and how this is a research institute, or a research school. So, the personalities aren't very similar to X and that matters. It matters giving out an idea of what the professor wants the class to be, for the students. And if the teacher doesn't really feel like using his or her own energy to express how it wants to be, then it sends like a, you know, kind of culture, instead of, "Let's learn!"

I: So, it seems to me, at least Talia and Igor, um, would say that the instructor influences this culture, this classroom culture, to a significant degree. I mean, do you guys agree? How much do students have to do with it? How much do your instructors have to do with creating that kind of culture?

Sophia: This is Sophia, um I definitely think that professors definitely do influence it a lot because I know that I've heard people say that in other classes, sometimes, a student may ask a question and the professor sometimes almost makes them feel dumb for asking it. So I feel like--and obviously in classes where the professors act that way, um, people are a lot less likely to ask questions and have their own personal input, um. But for her class it's definitely like you don't have to be afraid to ask her any questions and she's actually really excited when people ask questions. So I definitely think that what you're saying about it being more open, um, in the class, I think that's definitely true. And I think that's definitely influenced by the professor.

Talia: Um, this is Talia. Um, although I mentioned before that I didn't like it, I admire that like, she, like what she was saying before how you can say a wrong answer in class, and you won't be like, put down for it. And you can, I guess, I like that X caters the class to her. And, because, if you have different ideas about the subject, that's not necessarily about what we're learning, I feel like I wouldn't be afraid to talk to her about it, or to talk to the TA's about it. Whereas I know in my other classes, where the professors I could tell were here more for research than for teaching, they had the generic like, university given PowerPoint, and I was afraid to ask questions that veered off of the subject because I felt like the professor wouldn't wanna answer it.

I: If I was gonna walk into X 's class, and walk into a class like that. What would I sense that was different, you think, just walking in and seeing the class sitting there?

Talia: I think with a class like, with the generic professor, I think people frantically copying everything that's on the PowerPoint, not listening to the professor at all, because he will be just re-iterating everything that's on the PowerPoint, and um, then with Professor X her PowerPoints are mostly pictures, I think. There's like not a lot of words. And people are listening to what she has to say, because she's not looking off of them at all. And she's like explaining her points, which like, I think that's important.

Alice: This is Alice. Like Talia said, it's true. She only has pictures and then maybe some points. And she takes those points and she explains them, so it's really important to listen to what she's saying, otherwise you won't really know what's going on and what to write down. So, yeah I think um, she is much better than our other professors who take university PowerPoints and put them up. So I think yeah, she creates a personal feel to the class.

I: So I would definitely see a lot more people kind of, as you said, engaged, earlier in this conversation. More people kind of tuned in to what she's actually talking about, for instance. Go ahead Igor.

Igor: As Alice said, it depends on the day.

I: And the time of day?

Igor: Right, right. I mean, it's always at 11 in the morning, but it could vary like, some students might not be in the mood or might not even show up. But those who are there are usually like, "Okay, these are interesting things we're learning and that was a cool video we just saw." Um, I like that example, so.

Alice: This is Alice. I sit in the way back, so I see everyone, everything that's going on. Most of the students are usually like, in the PowerPoint, and paying attention, and like reading off slides and listening to what she's saying. I'd say most of the class is usually engaged in what she has to say.

I: Does this kind of culture that we've been talking about influence your guys' interest in this course?

Sophia: This is Sophia, I definitely think so. ‘Cause like I was saying earlier, um, how I feel like this class could be very dry and boring if um, if it didn’t' have this kind of atmosphere and if it didn't have the same professor. Um, I feel like, yeah, I feel like I could be very bored in this class. But just the fact um, that yeah just like the kind of culture we've been talking about, and her personality definitely makes me more interested in the subject material.

Talia: This is Talia. I think um, the fact that she has almost everyone coming to class and she still puts the PowerPoints online, that really says a lot about her because um, people want to go to class because she has interesting things to say, and you wanna catch it, and you know, take note of it. Whereas in other classes, where the professors that put it online, people wouldn't bother going to class because, the professor wouldn't bring anything to them that the PowerPoint wouldn't. And I think X does that. And, like, I mean attendance isn't mandatory obviously in a class that big, and I think that's important.

Alice: This is Alice. I think um, the enthusiasm and tune that X presents her topics, is very important to how we take it in, how interested we are X it. ‘Cause I've had some teachers, like, in one of my government classes, that are like so monotone that I can't even stay awake. The way she talks and she presents everything her like smile on her face, it just makes me want to be more interested in the topic.

I: Does the culture that you guys are talking about in this class, does it, um, I mean, and you know the experiences that you've had in this class so far, does it make you more or less likely to stick with your plans on your major? Or does it not affect that kind of decision at all?

Sophia: This is Sophia. Um, I don't think it affects my decision. I think it helps keep me motivated and interested in the class itself, but it doesn't change my mind on what I want my major to be or my future plans to be.

Alice: This is Alice, I agree with Sophia. Like, like I said earlier, what the teacher's saying doesn't really affect how, um if I wanna stay in the sciences or not, so.

Igor: This is Igor. Yeah, I mean, I agree with both of them. It's probably just a little reinforcement. It's nice to know that there's teachers and professors that aren't very dry in teaching the future citizens of the world, so.

Talia: Um, this is Talia. Um, same thing. I'm not really looking to go into this area of bio, so it doesn't really motivate me to stay interested in this. But um, in terms of like professors and classes, yeah. She gives you hope kind of.

I: Do you guys think that this course in particular is meant to weed out students?

Alice: This is Alice. I've heard that actually 105 is used to weed out students--

I: Which one is 105, I'm sorry.

Alice: Um, that's actually, for ______ for some reason, we take principles of biology 2 before we take principles of biology 1. So, ______ is more like the cellular stuff, so like photosynthesis and all those types of mechanisms are more--are introduced in that. So this one's more broader, uh broader topics and such. So I guess it's a little easier to understand than 105, which is the weed out class I've heard.

Talia: This is Talia. I've taken 105 last semester, and it's definitely a lot more di--like that's, like, that is the precursor for like, this is like a real like, science slash medical class, like this is the real deal. So I think that would be a weed out class, I don't think this is, though.

Sophia: This is Sophia. Um, I can kind of speak from like, um on the--specifically for Dr. _____ like her class, I don't really think that it's a weed out class. Obviously you're going to have students in any class that aren't going to do as well, and I mean she's fine obviously with giving them bad grades if they completely deserve it. But when I said earlier that I talked her, in an interview for another class and I asked her what um, she liked and disliked most about teaching. And she said what she disliked most about teaching was um, grades, and how important they were, and how she felt like they kind of restricted students freedom to like, understand things in their own way and things like that. So, for her--and she also gave me back two points on my exam when I went and explained my point of view on what I thought the question was asking, like why I thought this was like a good answer. And so she's very open about things like that, and she doesn't like to be especially harsh for no reason, especially like, with her as a professor I don't really think it's a weed out class. But like I said, that's not to say that she's just going to give everyone an A or anything.

I: Anybody else? We only have a few minutes left, so I'm just--lemme just look through the rest of my questions and make sure that, see what we've covered and what we haven't. We talked about, um, aspects of classroom culture in other classes, and it seems like chemistry has kind of come up a lot for some reason. Why is that? Igor.

Igor: I would probably consider like just Chem ______ as a weed out course. Just in the interest in sciences in general, for like STEM. Um, if you can't--if you can't, you know, get a good feel for that, it will probably hinder someone's confidence in going into the sciences and technology, so.

Sophia: This is Sophia. Um, I definitely think for chemistry that's a course where it builds and builds and builds, like each step you take, each higher class that you take. So, if you don't do well in Chem 1, that's really not a good sign, because you need to know all that material really well to succeed in Orgo, and Orgo 2, and Chem 2. But for a class like this, this is Biology, Ecology basically, and like she was saying, a lot of students here, not all, but a lot of students here take BSci ______ before BSci ______, and that just shows that they don't build off of each other--they're completely separate topics. So--

I: So somebody could take ____ first, but, I mean--

Sophia: Yeah, she did, so um, they're just completely unrelated--

I: That was Talia.

Sophia: One's like cell bio, and this is more like ecology. So, um, so you could not do well in this class and then still go on to other biology classes and still be okay. Um, whereas in a course like chemistry, you know that you're going to need to remember the stuff and need to know it for like your next chemistry course.

Talia: This is Talia. I think that what Sophia was saying was kind of true, if you are specializing in bio. However, if you were a chem major, it would be entirely different because I know for bio, there are a lot of bio classes at ______, but for the major you're not required to take every single one, but for some reason you're required to take every single general chemistry, every single organic chemistry, and then not the specialized chemistry, obviously. But, it's hard because that's not what you're interested in, yet you still have to do well in it. So I think that's what makes it hard. And also, yeah. And then I know for chem majors, they're not required to take a lot of bio classes, um.

PERSISTENCE SEGMENT

I: I'm gonna try to get--we only have a few more minutes left, so I'm gonna try to get you guys to the end. I appreciate your patience thus far, you guys have been awesome. So we've been talking about--we just talked about classroom culture, before that we talked about advising and stuff that you do outside of class, the ways Dr. ______ teaches in class and how that helps and--it mostly helps, you guys didn't really have a lot to say about hindrances or whatever, but. If you're thinking about things that--and again this study is broadly about why students sometimes choose to leave the sciences and why they sometimes decide to stay. If you guys were gonna talk about what influences your decision--your decisions--and Alice, you spoke to this a few times, about staying in your major, or deciding to switch out of your major. Can you talk to me about how you make those decisions? I mean I know this is something you guys think about everyday as you're going to the classes that you're going to, but can you talk to me a little bit more about that?

Alice: This is Alice. Personally, like I said earlier, it's mostly my decisions. Since I was younger, I've had interest to go into the sciences. But I have a friend, who, her parents are pushing her to go into the sciences. So she's on the edge of it, and she's actually not doing very well in chemistry. So because of that, she's thinking about maybe dropping chemistry and going into business. So I guess if you've had an interest since you're younger to go into the sciences, you'll stick with it no matter what and go through whatever hardships you have to go. But if you're on the edge, like my friend was, um like maybe if you encounter a hard class, you'll completely like drop the class, drop the sciences, and switch to something else.

Sophia: This is Sophia. I pretty much agree with what you're saying. I don't think you have to have an interest in it since you were little or whatever. But I definitely think for me, the two most important things are interest and also difficulty--in a way, um, it doesn't scare me if I go into a class and it's difficult and I think I'm gonna have to work hard, but since I um, my plans are to go to medical school or at least some kind of graduate school, I know that if I start doing really poorly in all my science classes and I just feel like it's not something that I'm meant to do and I know that I'm not gonna succeed at it, I obviously shouldn't continue trying to be a biology major because it's probably not the best choice for me. And I know, like people trying to get into medical school, if you have all B's, that's pretty tough. So while other people may be happy to have a B, it's really not gonna--you couldn't possibly have nowhere to go after college and be stuck with a biology undergraduate degree and not really know what to do with it. So, difficulty doesn't scare me but I know that if I just couldn't keep up at all and sciences ended up being something that I felt like wasn't a good fit for me because it was just conceptually above me, then I would drop it, because I would feel like I wouldn't be able to go anywhere with it.

Talia: Um, this is Talia. I think it's, like it's important to be interested in it a little bit, but it's also just really important to know that I think science classes are very much structured differently than other classes. Because, in a lot of science classes, there aren't assignments. It's just usually three major exams, and then a final, and then maybe a couple lab reports on the way. And so there's not a lot of room for you to make mistakes. So I think it's important to know how to take these classes. And even though you may be interested in the material, that doesn't mean that you should be necessarily a doctor, because, like, being interested in it won't get you through medical school. You have to know how to study for these exams and take these exams. It's sad that that's the main goal in order to become a doctor, but like, that's the only way, so. Know how to play the game.

Igor: Igor speaking. Um, for me you know you have an idea, you have a goal of what you wanna do in life. This is all gonna pass, everything's gonna just be done with, and it's a matter of like, what you ultimately wanna do with your life. I'm interested in biology, but like, again you gotta learn how to take the tests, you gotta learn how to be able to do well in these classes. Just an interest in itself won't really do too much--it will probably stick some ideas in your head better than others. For me, I just know that this is what I need to go through to get to this level, to get to this level, to get ultimately to where I wanna--

I: So the motivation is the goal. The ultimate goal, and not necessarily being interested in what's happening in that class, or seeing a teacher that's really enthusiastic about the subject matter?

Igor: Right, I mean like those things all build up upon each other. Like you can obviously taking chemistry, biology, math and all that, you can see how they all kind of give you a better understanding of what's going on around you every day. But um, you don't need that. You just need to get through it.

I: I'm gonna switch gears a little bit here with the last few questions. Do you guys think that based on your circumstances, or circumstances of friends or anybody else you know in programs that you're in--do you see economic circumstances like financial aid and the need to work a part time job, career aspects, do you see that affecting people's decisions to stay in the sciences, or to leave?

Talia: Yeah. This is Talia. Um, yes definitely I have friends who are not choosing to go to medical school because of the cost. And they're choosing to do PA, or pharmacy instead because that's in their budget. Which is kind of sad, because you know that they could become a doctor if they wanted to. But yeah, I think financial problems definitely play a big part into that.

I: Anybody else have an opinion on that?

Alice: This is Alice. I agree with Talia, but I think that if you really work hard--like I know there are scholarships out there, there are a lot of opportunities you can use to get you through medical school, but even though it's really difficult, especially like working part time and going to medical school, that's almost unheard of. But, I feel like, if they really had a passion, and maybe like, they have some hope, they would try their hardest and go for medical school.

Igor: I agree with both, I guess. If you really, really, really wanna do this, and you know for sure--you know, people aren't 100 percent confident about "This is how I wanna go about life," like, you'll get what you ultimately want. Hopefully you make all the right decisions. Sometimes it doesn't happen immediately, but eventually if you keep maintaining that goal, you'll fail, but you'll hopefully achieve it. Again, the financial aspect of it is horrifying. A lot of students um, I know a friend, he received financial aid for the first two years and then was cut off. He almost had to drop out, because it's just a lot. And personally I'm commuting just to save money so I can keep on going and finishing my four years here. So it plays a huge factor, but um, you know it also depends. If you wanna, if you wanna do pre-med or something, I feel like you gotta keep going, you gotta keep advancing, that's even more financial obligation, you know?

I: Sophia, what do you think?

Sophia: Um, I think that specifically talking about medical school, like what Talia was saying, I think that can definitely deter people, the financial aspect of it. Um, my um, my mom's a nurse, and she worked full time at a hospital while putting herself through nursing school, which is a ridiculous amount of work. Um, but, and she says now that if she could go back and do it again, she would have just gone to medical school. But my guess is that the financial side of that was probably what was holding her back. She didn't really have any aid from her parents, she had to put herself through um, so, that definitely was a big, um, aspect of the decision for her.

I: Sure. Do you guys think that issues related to race, ethnicity, gender, present any special challenges or opportunities to pursuing a degree in your field?

Igor: I mean, you might have a family where most of them have a medical background--that would definitely be an influence. But, when it comes down to it, it's just a situation. You know? All the things that you're given in life, your resources and stuff, it all influences where you're going to go kind of. But um, you know you see all sorts of diversity when it comes to a certain major. You might see more than others, but you'll see diversity. It's not just 100 percent of a certain kind or a certain group of people. That's why I'm saying it's very situational, it depends on which member is gonna go to a certain major or field.

Sophia: This is Sophia. I think that the sciences have done a great job in offering opportunities to people of different ethnicities and races and things like that, financial backgrounds, everything. And actually I think that a lot of times people, um minorities, and people with financial, um, problems, often have more opportunities. I was at a neuroscience club meeting, and someone came from a large research university talking about a summer research program, and they basically said, "This is good for people of either low financial fam--low income families, or minorities." And I was just thinking, "That's awesome for them, but that's completely ruling out my chances of getting into this program." And I think there are a lot of programs like that, and I think it's good in some ways, because um, those are things that those kind of people struggled with before, so it's good that there are more opportunities for them now. But it's actually becoming a lot harder for people like me, who are now looking into a lot of these programs, and I keep looking into these summer research programs and repeatedly see, "Apply if you are from a low income family, or a minority," or, "Good chance for people like that." So, that actually is more of a struggle for me.

Alice: Uh, this is Alice. Um, I agree with Sophia and what she said about how it really is helping minorities, and so sometimes--like I know, I'm Indian so I know there are a whole lot of Indians in the science fields. So I feel like sometimes it may work against me when I'm applying somewhere, because I know a lot of people of my race will be applying too, and sometimes I feel like that may work against me. So I feel like it is good, like what Sophia said, that it's helping out minorities, helping them get involved with the sciences, but like I said, sometimes I feel like it's working against me.

I: Sure. Talia, do you have anything?

Talia: Um, no I don't think so.

I: Sure. Um, do you guys think that racial and gender identities shape somebody's sense of belonging in the sciences? Or their identity as a scientist? I mean from your experience or the experiences of your friends?

Alice: This is Alice. Like I said earlier, it does. I feel like it sort of does shape my view of it, because I know many of my relatives, they're all doctors and such. So like if I feel like to be a doctor would be to fill the identity I have as maybe, as an Indian. So, yes I do feel like sometimes um, your race maybe has some sort of impact on the identity you have on the science community, but um, I think maybe overall for most people it doesn't really have that big of an effect.

Talia: Um, this is Talia. Um, I agree with Alice, but like, for me I kind of see it in an opposite view, I guess. 'Cause my family isn't all like that, and a lot of the kids in my family that have gone through school have kind of failed when leaving school. And so I'm kind of motivated by that because I don't want that to be my outcome. I guess I'm motivated by the opposite of what she's saying, I guess.

Igor: Um, this is Igor speaking. I mean, I agree with all of that, but there's also something to take into account when it comes to just the individual. I know I said this before, but um, there's--everyone's capable of doing what it is that you really want to do. And like, it shouldn't be restrictive if like, "Oh, do I belong here?" It should be, "Well, do my thoughts fit in, or do they help benefit this overall area of study?" And if it does, then like, go for it. Why should you be restricted by the idea that there aren't people like you? You might find someone that may not fit the same category of like race or ethnicity or something, but they have similar thoughts. And then you connect there. That's more important, I think to pay attention to when it comes to um, that whole idea.

I: Any other comments or ideas? Do you guys have any questions for me before we rap up? Do you think there's something that I should have asked that I didn't? Or, do you think I spent too much time on something that I shouldn't have?

Igor: I think you're good.

I: Do you think that um, if you think about the questions that I asked you guys during this focus group meeting, do you think that we are paying attention to the things that we should pay attention to when it comes to students staying in the sciences or not staying in the sciences? What's your impression?

Sophia: I think that definitely um, also for me it's more about grades, personally. Like I was saying before, if I knew that I was getting--that I was trying my hardest and getting all B's, I would probably change my mind about what I wanted to do, or like B's and C's or something. Because knowing that I wanna go to medical school, and looking at average GPA's and things like that--I mean I know like, there are definitely many other factors that go into it, but it's very competitive. And if I knew that I had a very low chance of getting in, I wouldn't see any reason for me to use my next four years still trying to pursue something that wasn't going to happen for me. So I think that maybe, that grades are probably like a big thing that change people's minds.

I: And when you were talking about that, you said, like, the option would be just to stay and get grades that would only allow you to end up with a biology major for college, right? And that was about--I'm asking now, was that also about your career prospects?

Sophia: Definitely. I mean I--my goal now is to go to medical school to become a doctor, and kind of my back-up plans kind of are PA school, maybe PT school--that's kind of my lowest back up. Um, but those are all graduate programs and those are all competitive to get into obviously. So, yeah definitely the caree--knowing, there needs to be a safety net for me, like I need to know what I'm going to do with my life, I need to know that I'm going to be able to pursue a certain career. And if I thought that my career was gonna be uncertain because I couldn't reach my goals to get there, I didn't have good enough grades to reach a certain career, and I wouldn't know what I would do with just an undergraduate degree in biology--that would really scare me. I wouldn't graduate with just that knowing that I couldn't continue.

I: You guys think we're on the right track? Talia? Alice? You can definitely say no. Might be more helpful if you did, actually. Any more questions at all, guys? (END INTERVIEW)

Appendix G: Institutional Review Board Authorization Agreement

Name of Institution or Organization Providing IRB Review (Institution A): UNIVERSITY OF COLORADO-BOULDER
OHRP Federalwide Assurance (FWA) #: 00003492
IRB Registration #: IRB00000191

Name of Institution Relying on the Designated IRB (Institution B): **UNIVERSITY OF WISCONSIN – MADISON**

OHRP Federalwide Assurance (FWA) #: **FWA00005399**

The Officials signing below agree that (Institution B): **UNIVERSITY OF WISCONSIN-MADISON** may rely on the designated IRB for review and continuing oversight of its human subject research described below:

This agreement is limited to the following specific protocol(s):

Name of Research Project: Talking About Leaving Revisited: Exploring the Contribution of Teaching to Undergraduate Persistence in the Sciences

Protocol Number: # 12-0343

Name of Principal Investigator: Anne-Barrie Hunter

Sponsor or Funding Agency:
ALFRED P. SLOAN FOUNDATION Award Number, if any: 2012-6-05

NATIONAL SCIENCE FOUNDATION Award Number, if any: In process in OCG

The review and continuing oversight performed by the designated IRB will meet the human subject protection requirements of Institution B's OHRP-approved FWA. The IRB at Institution A will follow written procedures for reporting its findings and actions to appropriate officials at Institution B. Relevant minutes of IRB meetings will be made available to institution B upon request. Institution B remains responsible for ensuring compliance with the IRB' s determinations and with the terms of its OHRP-approved Assurance. This document must be kept on file at both institutions and provided to OHRP upon request.

Signature of Signatory Official (Institution A): Joseph G Rosse Date: 11/26/12

Print Full Name: **Joseph G. Rosse, Ph.D**.

Institutional Title: **Associate Vice Chancellor for Research Integrity & Compliance**

Signature of Signatory Official (Institution B): Daniel Uhlrich Date: 11/13/12

Print Full Name: **Daniel J. Uhlrich, Ph.D.**

Institutional Title: **Associate Vice Chancellor for Research Policy**