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ABSTRACT

Title of Document:	THE RELATIONSHIP OF SCIENCE IDENTITY, SCIENCE SELF-EFFICACY, AND PSYCHOLOGICAL SENSE OF COMMUNITY TO STEM GRADUATE SCHOOL ENTRY AMONG MEYERHOFF SCHOLARS
	Rukiya A. Moraga, Doctor of Philosophy, 2021
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Over the course of the last few decades, there has been a push to diversify the field of science, technology, engineering, and mathematics (STEM) through the recruitment of underrepresented minorities (URM) to pursue undergraduate and graduate degrees in STEM. A body of research has demonstrated that graduates of the Meyerhoff Scholars Program (MSP), a multi-component, predominantly URM STEM intervention at the University of Maryland, Baltimore County, are more likely to pursue STEM graduate study. However, the latent mechanisms of influence for the MSP and similar interventions warrant further study. To address the need for understanding these pathways of influence, the current study investigated the relation of science identity, science self-efficacy, and psychological sense of community with STEM graduate program entry, including mediational relations, and the potential moderation effect of gender on significant mediational relationships. Results demonstrated that, while there was some support for psychological sense of community being an important precursor to STEM graduate pursuit, science identity was the strongest predictor of STEM doctoral entry. Additionally, there was no support for gender as a moderator of significant mediational relations. Study implications, limitations, and recommendations for future research are discussed.

THE RELATIONSHIP OF SCIENCE IDENTITY, SCIENCE SELF-EFFICACY, AND PSYCHOLOGICAL SENSE OF COMMUNITY TO STEM GRADUATE SCHOOL ENTRY AMONG MEYERHOFF SCHOLARS

By

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Dissertation submitted to the Faculty of the Graduate School of the
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Dedication

I dedicate this dissertation to my Creator and Life Giver – the One without whom I would not be. I also dedicate this to my mother and father who, from a young age, instilled in me the love of learning and the pursuit of excellence.

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Table of Contents

List of Tables

Introduction

For years there have been low numbers of underrepresented minorities (URM) in science, technology, engineering, and mathematics (STEM) fields. In response, policy makers, educators, and others have tried to increase the numbers of women and underrepresented racial/ethnic minorities (i.e., African-Americans, Latino/as, Alaska Natives, Native Americans, and Native Hawaiians/Pacific Islanders) pursuing STEM degrees. While the proportion of URM who earn STEM bachelor's degrees has been increasing since 1995, progress is uneven and slow. For example, the percentage of African-Americans who earn bachelor's degrees in the biological sciences is increasing, while the portion who earn degrees in math and statistics has declined (National Science Foundation, 2019). Additionally, in 2017 women represented approximately 47% of the entire workforce. Nevertheless, women made up only 15.1% of the science and engineering workforce (National Science Foundation, 2019). That the percentage of women in science and engineering is not reflective of their size in the population indicates that women are underrepresented in this field. Likewise, in 2017 individuals from URM racial/ethnic groups comprised approximately 28% of the population of the United States but represented a mere 9% of all STEM doctorate degree holders and approximately 16% of full-time STEM workers (National Science Foundation, 2019). Hence, these individuals are underrepresented in both STEM degrees and also in the STEM workforce. To enhance scientific innovation, problem solving, and economic growth in the United States, increasing the numbers of women and URM in the STEM field is vitally important.

Educational stakeholders have invested a substantial amount of time, energy and money in the development and administration of programs to increase diversity in STEM, especially at the undergraduate level. One of the most successful interventions to date is the Meyerhoff Scholarship Program (MSP) at the University of Maryland Baltimore County (UMBC; Maton et al., 2016). The MSP is a multi-component program that recruits a diverse group of high achieving graduating seniors interested in pursuing a STEM major. The MSP provides support (e.g., full scholarship, tailored mentorship, research experiences, community of learning, social support, tutoring, career and academic advising) to overcome barriers to science achievement. A body of research suggests that MSP graduates are more likely to pursue a graduate degree after completing their undergraduate degree than other similar students who did not participate in the program (Maton et al., 2016; Maton et al., 2012; Maton et al., 2009).

Although research has consistently shown that STEM enrichment interventions like the MSP help to increase overall retention and graduation rates of underrepresented minority students and women in STEM fields (e.g., Carrino & Gerace, 2016; Casad et al., 2018; Dagley, Georgiopoulos, Reece & Young, 2016), we have yet to understand the mechanisms behind this change. In particular, the mechanisms through which this program influences students and how those mechanisms affect the trajectory of students' movement into graduate programs are understudied. Among the factors and components of STEM interventions like the MSP, three that have begun to be examined in the literature were the focus of the current study: science identity, science self-efficacy, and psychological sense of community. The aforementioned constructs were the variables of interest in the current study due to the MSP's emphasis on their development through a cohort-based Summer Bridge Program (a 6-week intensive STEM "boot camp" experience), program-wide "family" meetings, mentorship, advising, and research experiences, among other factors.

The proposed study sought to elucidate the relationships between science identity, science self-efficacy, and psychological sense of community and entrance into STEM graduate programs among Meyerhoff students who entered UMBC in the summers of 2014, 2015, and 2016. For each construct, the literature review begins with an overview of the relevant theory followed by a review of the empirical literature related to the variable and STEM outcomes. The potential influence of demographic characteristics such as gender and race/ethnicity are also discussed in each section.

Science Identity

Theories of Identity Development

Three main identity theories through which science identity may be conceptualized are identity stage theory, social identity theory, and multiple identity theory.

Identity stage theory posits that identity development takes place in stages over time. Based on Erik Erikson's work in the 1950s, the theory views human development as occurring in eight stages, from birth to late adulthood (Meyers, Ohland, Pawley, Silliman & Smith, 2012). Each stage has a crisis that must be resolved. With each crisis that is overcome, the individual gains competence and mastery. These stages include: trust versus mistrust, autonomy versus shame/doubt, initiative versus guilt, industry versus inferiority, identity versus role confusion, intimacy versus isolation, generativity versus stagnation, and integrity versus despair (McLeod, 2013). Modern identity stage theory further argues that each person develops and reaches various stages at his or her own pace, gradually, until the last stage (Meyers et al., 2012).

Social identity theory is grounded in the idea that what someone understands about himself or herself and how others view that individual is positioned within a social world (Stets & Burke, 2000). Specifically, this theory denotes that one's identity is based on being a member of a social category or categories, which is a group-based identity. According to this theory, identity is not only an individual construction, but one that has organizational and institutional components that work in tandem to shape one's personal identity as well as a "collective identity" (Patrick & Borrego, 2016; Stryker & Burke, 2000). In particular, social categories are part of the structures of society, which define who has power, prestige, and status (and who does not), and people maintain their self-concept through these groupings. Having a specific social group identity means taking on the group's perspective, having a strong affinity for the group, and behaving in a manner that reflects the group with which one identifies (Patrick & Borrego, 2016).

Social identity theory differs from multiple identity theory, based on Gee's (2000) work that identity is being a "certain kind of person." In this recognition that one is a certain "kind" of person, one also has interaction and intersection of four identities, with each being more or less prominent, depending upon the context. These four socially and culturally informed identities are one's nature identity, institutional identity, discourse identity, and affinity identity (Patrick & Borrego, 2016).

Gee theorizes that one's nature or natural identities are only so because of recognition by oneself or others that he or she is this "kind" of person. In essence, a "nature" identity is given credence because of the attention drawn to it through institutions, discourse, or affinity groups (Gee, 2000). On the other hand, institutional identity is one that is given through authorities or authorization. This identity is not necessarily one that is "natural" to someone; rather, it can be an identity that is attributed to or imposed on someone. The third identity is referred to as the "discursive" perspective. Essentially, this identity is one that is given to someone by others because of how others treat or talk about the person; that is, the source of the identity is neither through institution nor nature, but rather through recognition by other people (Gee, 2000). The fourth identity, affinity group, is a manner of looking at who someone is by examining their membership in a group that shares a set of common practices, and participation in activities that are required for being a part of said group (Gee, 2000).

A person's various identities may be leveraged and negotiated such that the individual may only be recognized primarily as a particular identity (Patrick & Borrego, 2016). For example, through varied ways of speaking or writing, interacting or acting, dress, and the use of technology, one may be "seen" in a particular way as a certain "kind" of person. According to this theoretical framework, one may be consciously and continuously making and unmaking aspects of one's identity (e.g., making some aspects more salient than others) in order to maximize an advantage or meet a need in a moment (Patrick & Borrego, 2016).

Summary. Through identity stage theory, social identity theory, and multiple identity theory, it is posited that a person's identity may be dynamic, not static. Additionally, context is important. That is, aspects of a person's identity may be influenced by the surroundings, the group one is part of, and how an individual feels. Of particular importance is the aforementioned notion of a "nature" identity (Gee, 2000) and how one may be viewed by oneself and others as a specific "kind" of person in a given context. This is the basis from which science identity is defined.

Defining Science Identity

Numerous researchers have described science identity as involving self-recognition and/or recognition by others as a "science person" or, relatedly, how much one identifies as a scientist or potential scientist (e.g., Hazari, Sadler & Sonnert, 2013; Robinson, Perez & Carmel, 2019; Stets, Brenner, Burke & Serpe, 2017). Carlone and Johnson (2007) further posit that science identity is not only recognition, but a triangulation of performance and competence as well. They note that science identity is indeed socially constructed and does not function in a vacuum, but is influenced by various other identities including racial, ethnic, and gender identities that interact with one's science identity (Carlone & Johnson, 2007). Performance consists of the "doing" of science, such as one's manner of talking and utilizing equipment. Competence, while less visible, consists of one's knowledge and understanding of science content.

Furthermore, science identity, according to Carlone and Johnson (2007) is born of what is available in a setting and is more than what someone feels or does. Rather, science identity develops when someone has the competence of knowing the material, the performance ability to utilize needed tools, and is recognized by others who matter to the person, that he or she is a "science person." Moreover, science identity is deemed to be both constructed and emergent in situations, and may be varied or stable over time (Carlone & Johnson, 2007), consistent with multiple identity theory. The following section describes the significance of science identity.

Importance of Science Identity

Multiple studies have found that undergraduate students' science identity is associated with entry into STEM graduate school (Estrada, Woodcock, Hernandez & Wesley Schultz, 2018; Maton et al., 2016; Merolla & Serpe, 2013), science careers (Robinson, Perez, Nuttall, Roseth & Linnenbrink-Garcia, 2018; Stets, Brenner, Burke & Serpe, 2017), persistence in STEM majors (Chang, Eagan, Lin & Hurtado, 2011; Guy, 2014; Lu, 2015), and intent and commitment to pursue a STEM major in college and a STEM career upon graduation (Chemers, Zurbriggen, Syed, Goza & Bearman, 2011; Byars-Winston & Rogers, 2019; Estrada, Woodcock, Hernandez & Wesley Schultz, 2011). Relatedly, science identity is also positively related to academic outcomes, such as science achievement (e.g., Lu, 2015; Robinson, Perez & Carmel, 2019; White, DeCuir-Gunby & Kim, 2019).

Research demonstrates the importance of science identity to success in STEM; however, across the American college student population, science identity is low, especially for women (Ceglie, 2011) and underrepresented minority (URM) students (e.g., Alston, Guy & Campbell, 2017; Hazari, Sadler & Sonnert, 2013). Researchers index various reasons for the lower science identity of women and URM students, compared to male students and white students. Schinske, Cardenas, and Kaliangara (2015) found that scientist stereotypes affect students' relations with science. Specifically, students were found to have a certain idea of who scientists are and what scientists look like. Indeed, the less the students' images of scientists looked like them, the less they believed they could succeed in the sciences. Another related reason offered for the low levels of science identity in women and URM students are stereotypes. That is, negative stereotypes of women and URM STEM students cause can cause anxiety, which is related to decision making (Carr & Steele, 2010), performance impairment, and decreased confidence (Beasley & Fischer, 2012; Kapitanoff & Pandey, 2017; Steele, 2010). Depending upon situational attributes, some URM students may be more susceptible to such stereotype threat than other URM students (Chang, Eagan, Lin & Hurtado, 2011). Furthermore, especially for Black students pursuing STEM, science identity is interrelated with the negotiation of racial/ethnic identity (Flowers III & Banda, 2019; Malone & Barabino, 2009).

Indeed, students' engagement in science is seen as molded by how much they identify as scientists (Brickhouse, Lowery & Schultz, 2000) and in turn, how much they are socialized through home and school to have interest in "science things" (Jackson & Suizzo, 2015). Science identity also influences pathways in science (Krogh & Anderson, 2013; Martin-Hansen, 2018), and students' decisions and thought processes during graduate school and post-doctoral positions regarding whether or not to pursue a science research career (Price, Kantrowitz-Gordon & Gordon, 2018). The next two sections review empirical studies specific to the patterns of relation between science identity and academic achievement, and science identity and intent, persistence, and commitment to science, respectively.

Science Identity and Academic Achievement

Several researchers have focused efforts on the relationship between science identity and science academic achievement. This relation was one of the foci of a recent study by White, DeCuir-Gunby, and Kim (2019), who studied the relationship between these variables for African-American students at historically black colleges and universities (HBCUs). Their 347-person sample predominantly consisted of second year STEM students at five HBCUs in the southeastern United States. Utilizing the reliable and internally consistent science identity scale developed by Chemers et al. (2011; alpha ranges from .89 to .96), their cross-sectional path analysis found that science identity is important in that it significantly explains science achievement through mediation by science self-efficacy.

A longitudinal study of science identity development in an introductory science course at a large public predominantly white institution (PWI) found that final exam scores were highest for those with "high and stable" science identities, as compared to students with "moderate and slightly increasing" and "moderate and declining" semester trajectories (Robinson, Perez, Carmel & Linnenbrink-Garcia, 2019). These three distinct science identity subgroups were found through latent growth and growth curve modelling in response to the authors' interest in examining how science identity may change during STEM students' first science course in their first semester of college. The sample was approximately 55% female, 73% white, 14% Asian, and 6% African-American. Robinson and colleagues measured science identity at weeks two, four, and fourteen with a scale used by Robinson et al. (2018; alpha = .85-.87) that was adapted from Pugh, Linnenbrink-Garcia, Koskey, Stewart, and Manzey (2009) and Conley (2012). A qualitative analysis of male Latino college students in central Texas also found that a strong science identity is related to success in the first semester of college (Lu, 2015).

Summary. The results of these studies help to establish the importance of science identity to science academic achievement; however, there are limitations to the research to date. Two of the studies (Lu, 2015 and White, DeCuir-Gunby & Kim, 2019) were cross-sectional, thus they only capture a snapshot in time of students' science identity, rather than a prospective analysis. Additionally, Lu (2015) was limited to Latino male students, and White, DeCuir-Gunby, and Kim (2019) only examined the experience of African-American students who attended HBCUs. Further research is needed to expand the generalizability of findings. For example, in the context of African-Americans, non-HBCU institutions graduate 75% of African-Americans with STEM bachelor's degrees (United Negro College Fund, 2019).

Science Identity and Intent, Persistence, and Commitment to Science

Strong science identity is also related to persistence in a STEM major (Chang, Eagan, Lin & Hurtado, 2011; Guy, 2014; Hernandez, Wesley Schultz, Estrada, Woodcock & Chance, 2013). Hernandez, Wesley Shultz, Estrada, Woodcock and Chance (2013) conducted a longitudinal study that examined the relation between growth in science identity and achievement goal orientation and motivation. Findings revealed that higher science identity was positively related to an "approach" goal orientation (i.e., a focus on success), and negatively related to avoidance orientation (i.e., a focus on avoiding failure). The authors also found, in turn, that "approach" goal orientation was positively related to persistence in the STEM major. Their study was conducted across three academic years and 38 universities, with a total of 1,046 high achieving African-American and Latino students, of whom the majority were in science enrichment programs for URM students. Data collection began in the junior or senior year and continued for five waves (fall and spring). Science identity was measured using a reliable and consistent scale adapted by Estrada et al. (2011) from Chemers et al. (2010).

Chang et al. (2011), utilizing longitudinal survey data provided by the Higher Education Research Institute (HERI), conducted hierarchical generalized linear modeling and found a significant positive relationship between identification with STEM and persistence in a STEM major through the first year of college. The sample of 1,745 URM freshmen respondents from 123 college/universities was approximately 75% female, with over 50% from private institutions. Of note, a limitation of this study is that a formal science identity scale was not utilized. Instead, the authors used "domain identification" to measure students' interest, commitment, and performance in their STEM field. Participants indicated how personally important were "recognition from colleagues for contributions to my field," "becoming an authority in my field," "making a theoretical contribution to science," and "working to find a cure to a health problem." Higher scores on these items were considered greater identification with their STEM major, reflecting a higher science identity. Cronbach's alpha was adequate at 0.70.

Similar to the aforementioned studies, Guy (2014), in a cross-sectional study of 378 African-American first and second year students at six universities in North Carolina, found that science identity significantly predicted intention to persist in science. However, while this study supported prior studies linking science identity to persistence, the science identity measure was created from matching two scales that measured, respectively, preconceptions about scientists, and students' sense of self. Guy reported adequate Cronbach's alpha for the scales (0.84, 0.77, and 0.85, respectively).

Several studies further sought to connect science identity to the intention or commitment to pursue a research career (Byars-Winston & Rogers, 2019; Chemers, Zurbriggen, Syed, Goza & Bearman, 2011; Estrada, Woodcock, Hernandez & Wesley

Schultz, 2018). Chemers et al. (2011) cross-sectionally examined 665 URM undergraduate and graduate students from 50 universities and those who graduated within the last three years, but did not matriculate into graduate school, via online survey through the Society for Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS). The convenience sample was approximately 50% Latino, 15% Asian-American, 12% "mixed URMs," 11% white, 9% African-American, and 4% Native American. Chemers and colleagues (2011) conducted structural equation modeling to test whether science identity mediated the relation between science support experiences (e.g., research experience, community involvement) and commitment to a career in science. Results showed that science identity fully mediated the relation between support experiences and commitment to work in a science field.

Another study tested path models to understand the relationship between science identity and the intent to pursue a research career (Byars-Winston & Rogers, 2019). The researchers found that science identity was significantly related to research career intentions indirectly through a positive relation with "outcome expectations" (the extent to which they agreed that a science career would benefit them and be satisfying). Administered at the Annual Biomedical Research Conference for Minority Students (ABRCMS), 688 undergraduates (42% African-American, 40% Latino) completed the survey. While the results are promising, there are measurement limitations to this study, namely that three measures have two or less items, which could translate to decreased content validity (Byars-Winston & Rogers, 2019).

Finally, Estrada, Hernandez, and Wesley Schultz (2018) found, using structural equation modeling, that science identity was a significant positive predictor of the pursuit of a scientific career. Students were from 50 universities across the United States that had URM-focused biomedical/science training programs. The authors conducted a cross-sectional survey of 719 URM undergraduate and graduate students, and participants who had a bachelor's degree but did not attend graduate school.

Research to date extends our understanding of the influence of science identity on intent, persistence, and commitment to a STEM major or STEM career. One limitation of these studies is that they only measured attitudinal constructs, which are not the same as behavior, and do not necessarily translate to actual behavior. To address this dearth in the literature, Stets, Brenner, Burke, and Serpe (2017) investigated the impact of science identity on entering a science occupation by utilizing a longitudinal dataset of URM students who were participants in science enrichment programs (57% of the sample) in 25 universities (HBCUs, Hispanic Serving Institutions, and predominantly white institutions) across 17 states, or whose demographic and academic profiles matched students who were in these programs (43% of the sample). Students were surveyed in the fall and spring, starting in fall 2005 (wave 0) through spring 2013 (wave 15). The outcome variable, science occupation, was measured from wave 10 and beyond by one item that asked participants who are not in school whether or not their current occupation is in a science field.

Stets and colleagues' (2017) measurement of science identity consisted of a four-item identity prominence scale with an omega reliability of 0.92. Items included "I have come to think of myself as a scientist" and "In general, being a scientist is an important part of my self-image." They utilized structural equation modeling to estimate the general linear model, and results indicated that science identity positively influenced moving into a science occupation after graduation. Additionally, URM students with stronger science identities were more likely to have a science occupation.

Another longitudinal study investigated the relation between the development of science identity and involvement in science careers or in a science field post-college using growth-mixture modeling (Robinson, Perez, Nuttall, Roseth & Linnenbrink-Garcia, 2018). Specifically, the authors' aim was to determine if there are multiple patterns of science identity development during college and if there are, whether these different patterns of science identity predict science career outcomes post-graduation. Data were collected from 1,023 students (43% Asian, 25% White, 13% African-American, 11% Latino, 8% other) at an elite, private American university over the course of five years (first year of college through one year after graduation). The outcome variable, science involvement, was assessed by one self-report item that asked, "Do you consider yourself to be involved in a science-related career or field?" Response options were "Yes," "Somewhat," and "Definitely not," along with examples of each. The examples for response category "Somewhat" were "science writer, investment advisor biotech, and drug regulatory affairs." The first two categories were combined for analyses.

Their results indicated that there were three trajectories or latent classes for science identity development: "high with transitory incline" (high science identity in the freshman year with a modest increase, then a modest decrease over the course of four years); "moderate-high and stable" (moderately high science identity to start with and negligible change over four years; "moderate-low with early decline" (low science identity to start with, then an abrupt decrease, followed by a steady decrease in the last two years of college). Students with science identities in the "high with transitory incline" and “moderate-high and stable” groups were significantly more likely to be in a science field or have a science career post-graduation than those with “moderate-low with early decline.”

Similarly, Estrada, Hernandez, and Schultz (2018) examined entrance into science fields with longitudinal growth curve analyses of science identity from year 3 through one year post-college. They surveyed 1,015 URM STEM students from 50 universities who participated in minority STEM training programs, and those who matched their demographic characteristics, beginning in their junior or senior year to determine if URM undergraduate students’ science identity positively related to a STEM career. Estrada and colleagues’ outcome of current occupation was measured in three categories. The first was “STEM Career,” which included graduate students in STEM and the attainment of STEM careers like a chemist or a science teacher. The second category was “Medical/Clinical Career,” which included being a pediatric resident or an occupational therapist, and the third category was “Other.” Using Chemers’ (2011) science identity scale, they found that science identity positively predicted persistence in a STEM career up to four years post-graduation. Moreover, they found that science identity was a negative predictor of leaving both STEM and medical careers but did not differentiate those who chose medical careers from those who chose research careers.

Summary. The evidence to date indicates that science identity is positively related to intent to major in a STEM field, persistence in STEM majors, and commitment to or pursuit of a science career. While several of the studies did have the advantage of utilizing longitudinal analyses, along with an actual behavioral outcome, there are some limitations and related gaps in the literature. First, two of the three studies have samples that consist of students who were all in different STEM enrichment programs in different universities with various components, and as Estrada, Hernandez and Wesley Schultz (2018) note, the components of the differing programs could not be standardized across participants. Additionally, one of the studies was conducted with students at an elite, private institution, which limits the generalizability of the findings (Robinson et al., 2018). Also, as the researchers note, their study had an overrepresentation of female, white, and Asian students, which might limit the relevance of findings for URM students. The current study will address existing gaps in the literature by utilizing a predominantly underrepresented minority sample of students who attend a predominantly white institution, and are a part of a single, well established and nationally recognized STEM training program.

Science Self-Efficacy

A second focus of the current study is the relation between science self-efficacy and the matriculation of Meyerhoff Scholars into graduate school for STEM. The next section will begin with a review of theoretical frameworks, along with a description of self-efficacy generally. This is followed by a review of the empirical research examining science self-efficacy, and its relation to academic outcomes.

Self-Efficacy and Social Cognitive Theory

Self-efficacy is theoretically grounded in Social Cognitive Theory, which posits that there is a dynamic, bidirectional exchange between an individual's external environment and his or her behavior and personal factors (Lent, Brown & Hackett, 1994). Such personal factors may be biological, affective, or cognitive (Bandura, 1986). Self-efficacy itself refers to beliefs about one's ability to do a task or perform a behavior (Bandura, 1977; Betz, 2000). Bandura (1977) proposed this construct, and he further elaborated that self-efficacy refers to a person's judgment of her or his capability to "organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Furthermore, this theory argues that individuals not only act on their consideration of what they are able to do (self-efficacy), but also what they believe will happen as a result of said action (i.e., outcome expectation; Bandura, 1986). For example, if a student studies consistently for a biochemistry exam, the student expects to earn a passing grade. Not only this, but the student's goal is to earn a passing grade. Social cognitive theory suggests that self-efficacy and outcome expectations influence a person's choice regarding goals, whether or not someone will initiate a behavior, how much effort is put forth towards goals, and how long one will sustain a behavior (Nauta, Kahn, Angell & Cantarelli, 2002; Rittmayer & Beier, 2008).

Self-efficacy is premised upon four sources of information: 1) performance accomplishments, 2) vicarious learning, 3) social persuasion, and 4) physiological reaction (Bandura, 1997; Flowers III & Banda, 2016). Performance accomplishments or "enactive mastery experiences" (Bandura, 1997) refer to past experiences that evidence an individual's ability to execute a task. Mastery experiences have been found to be the most important indices of self-efficacy (Betz, 2000; Flowers III & Banda, 2016). Bandura (1997) notes that this is because with each success, self-efficacy is built. On the other hand, failures hinder growth in self-efficacy, particularly if the individual has not securely established a sense of self-efficacy (Bandura, 1997). For instance, if a computer science student successfully fixed a complex program algorithm once, then she is likely to feel confident that she can do it again; however, if she was unable to fix the algorithm, she is more likely to doubt her ability to fix the subsequent problem.

Vicarious learning or modeling is the second source of self-efficacy. This refers to learning through the observation of others completing a task (Flowers III & Banda, 2016). Vicarious learning is particularly effective when the individual perceives greater similarity between themselves and the model (Bandura, 1997). Similar to mastery experiences, observing success can increase perceived self-efficacy, and observing failure can reduce perceived self-efficacy (Bandura, 1997). For instance, if a first-year graduate student observes a more advanced student complete a thesis, he may believe that he, too, is able to complete his thesis.

Social persuasion refers to feedback from others, or others' encouragement, judgment, and support (Flowers III & Banda, 2016). As noted previously, if this feedback is positive, it enhances self-efficacy, whereas, if the feedback is negative, self-efficacy diminishes. However, it should be clarified that social persuasion that is not accurate (i.e., social persuasion that surpasses the skillset or ability of an individual), would actually cause self-efficacy to decline because failures would become more persuasive than social persuasion that is unrealistic or not genuine (Betz, 2000; Rittmayer & Beier, 2008).

The fourth source, physiological reaction or emotional arousal, refers to the effect that emotional states have on self-efficacy (Flowers III & Banda, 2016). Physiological indicators include sweating, rapid heartbeat, and "butterflies" in the stomach. Situations that elicit stress could cause anxiety, leading an individual to doubt their likelihood of success, and this could lead to poorer performance (Bandura, 1977; Britner & Pajares, 2006; Rittmayer & Beier, 2008). Alternatively, if the individual learns coping mechanisms to manage this unwanted emotional arousal, self-efficacy is enhanced (Betz, 2000).

In determining whether or not an individual believes that a task can be done, it is important to assess the person's belief that is *specific* to the context of focus, rather than general. This means that one's self-efficacy must be in reference to a particular behavior, or domain-specific (Betz, 2000; Pajares, 1996). Self-efficacy can refer to contexts that are as different as teaching engineering and lifting weights; there are innumerable examples of specific self-efficacy. For the current study, science self-efficacy is the domain of importance.

Self-Efficacy and Social Cognitive Career Theory

Self-efficacy is also incorporated within Social Cognitive Career Theory (SCCT; Lent, Brown & Hackett, 1994). This theoretical framework explains the process through which academic and career interests form, career and education choices are made, and success in academics and career is actualized (Lent & Brown, 2006). SCCT considers an individual's personal agency as well as context and environment on career choices (Lent, Brown & Hackett, 1994; Tate et al., 2015). SCCT has been shown to be a robust structure through which to account for the why and how of students' development of career paths, particularly when students perceive themselves to be capable of being successful in a career and they have high outcome expectations (Berkes, 2007). SCCT has been increasingly utilized as a lens in the context of specific science academic domains, and determining persistence in completing academic goals over time (Larson et al., 2015; Luzzo, Hasper, Albert, Bibby & Martinelli, 1999). Specifically, SCCT argues that changes in self-efficacy directly impact goals, career choice, and actions/behavior. In like manner, the current study uses SCCT to frame the investigation of how Meyerhoff Scholars' personal factors (i.e., science identity, self-efficacy, and sense of community) within the context of the Meyerhoff program may impact their choice of post-college destination, including STEM graduate school matriculation.

As a STEM intervention, the Meyerhoff Scholars Program (MSP) aims to enhance the aforementioned components of self-efficacy, particularly science self-efficacy. Science self-efficacy is defined as the belief in one's own ability to perform science tasks, research, or activities successfully (White, De Cuir-Gunby & Kim, 2019). The MSP utilizes strategies aimed at increasing self-efficacy and interest in STEM research careers via the four sources of self-efficacy, but chiefly through social support (e.g., program leaders, faculty, staff, current/former Meyerhoffs, and parental involvement), and vicarious learning (e.g., the success of current/former Meyerhoffs, one-on-one mentorship, etc.).

Science Self-Efficacy and STEM Outcomes

A large and methodologically diverse body of literature associates science/research self-efficacy with numerous positive STEM outcomes, including science achievement in secondary school and college (e.g., Byars-Winston, Diestelman, Savoy & Hoyt, 2017; Byars-Winston, Estrada, Howard, Davis & Zalapa, 2010; Kaya & Bozdag, 2016; Kirbulut & Uzuntiryaki-Kondakci, 2019; O'Connor, 2018), science/research career choice (e.g., Deemer, Marks & Miller, 2017; Grunert & Bodner, 2011; Luzzo, Hasper, Albert, Bibby & Martinelli, 1999; Zeldin, Britner & Pajares, 2008; Zeldin & Pajares, 2000), and persistence in STEM (e.g., da Silva Cardoso et al., 2013; Lent, Lopez, Sheu & Lopez, 2011; Marra, Rodgers, Shen & Bogue, 2009; Trujillo & Tanner, 2014). Summaries of select individual studies that address science self-efficacy as a predictor and mediator follow. Of note, the following studies are correlational, rather than experimental. While self-efficacy may lead to academic outcomes, it is possible that academic outcomes also lead to self-efficacy, and the directionality of this relation is not fully clear given limitations of non-random assignment designs.

Science Self-efficacy as a Predictor

There have been over 20 studies of science self-efficacy as a predictor of academic outcomes among college students. The vast majority of studies have supported a positive association. A small subset of studies was longitudinal in nature, several of which are reviewed here. Larson et al. (2015) conducted a longitudinal study to investigate if science self-efficacy is predictive of graduation from college. The researchers sampled 280 students at a large mid-western university who were predominantly white (84%) and in their first year (mean age = 18.5 years). Across three fall semesters (years not reported), students in introductory science courses were asked to complete a survey regarding their math and science self-efficacy. Science self-efficacy was measured using Smith & Fouad's (1999) measure of science self-efficacy. Cronbach's alpha for the measure was reported to be 0.85. Controlling for students' prior performance (e.g., high school GPA), aptitude (e.g., Mathematics ACT score), and first semester GPA, analysis using binary logistic regression found that science self-efficacy significantly predicted graduation 4 to 8 years later. Limitations of this study for current purposes are that the authors examined graduation across all majors, rather than only STEM majors, and did not focus on URM students.

Another longitudinal study, conducted by Britner and colleagues (2012) examined the relation between science self-efficacy and progress towards a STEM career. They designed a 10-week summer research program for undergraduates who are underrepresented in STEM fields. The program included research experiences, neuroscience coursework, and team-based and one-on-one apprenticeship. During the summer of 2010, twenty-three female and thirteen male participants completed pre-, mid- and post-program surveys to measure their science self-efficacy using Chemers et al.'s (2001) self-efficacy scale. They also interviewed four participants. Their qualitative and quantitative analyses supported the notion that research self-efficacy predicts positive student outcomes and progress toward STEM careers.

Marra, Rodgers, Shen, and Bogue (2009) tested the relation between engineering self-efficacy and intention to persist for 196 women engineering students. Participants attended five public colleges in the eastern, southeastern, Midwestern, south central, and southwestern United States. Sizes of the institutions ranged from large to small, as did the location (urban and rural) and the demographics of the student body. Students completed the Longitudinal Assessment of Engineering Self-Efficacy (LAESE; Marra et al., 2005) in fall 2003 and 2004. Cronbach's alpha was reported to be acceptable, with subscale reliability ranging from 0.72 to 0.87. Marra and colleagues found that self-reported intention to persist in the engineering major was positively and significantly related to their self-reported self-efficacy.

While the previous studies show the vast variability in measurement, sample demographics and characteristics, they support the association between science self-efficacy and a range of positive outcomes. At the same time, and similar to the science identity literature, overall these studies highlight the dearth of studies that examine graduate school entry. Additionally, there were multiple variations of self-efficacy measures used, some of which did not have reliability and validity information. Furthermore, these studies do not have URM participants that are all in STEM intervention programming. The current study addresses these gaps and limitations in the literature.

Science Self-efficacy as a Mediator

Science self-efficacy may serve as a mediator for science achievement (Kirbulut & Uzuntiryaki-Kondakci, 2019; Trujillo & Tanner, 2014). A small number of studies have examined the role of science self-efficacy as a mediator between various predictor and outcome variables. Representative studies are reviewed below.

Adedokun, Bessenbacher, Parker, Kirkham, and Burgess (2013) hypothesized that there is a mediating effect of research self-efficacy on the relationship between research skills and students' desire to pursue a research career. The 156 participants in their study were students in an undergraduate research program at a Research I university in the Midwest between spring 2010 and summer 2012. The students were required to maintain a minimum 3.0 GPA and have sophomore standing. Additionally, they could choose to participate for a summer, or one or two academic semesters. Research self-efficacy was measured using five items modified from Kardash's (2000) self-efficacy scale. Cronbach's α was estimated to be 0.85. Adedokun and colleagues conducted structural equation modeling and results indicated that research self-efficacy predicted student aspiration for research careers, and partially mediated the relation between research skills and aspiration for a research career.

Byars-Winston and Rogers (2019) surveyed 688 attendees at the Annual Biomedical Research Conference for Minority Students (ABRCMS) in 2012 and 2013 using items adapted from existing measures, such as the Undergraduate Research Student Self-Assessment (URSSA; Weston & Lauren, 2015). Reliability and validity information was not reported. The authors conducted a series of path models to understand the associations between experiential sources of learning (i.e., performance accomplishments, vicarious learning, social persuasion, and emotional arousal) and intentions to pursue a research career. They found that research self-efficacy was directly and positively associated with research career intentions, and associations between learning experiences and intention to pursue a research career were mediated by research self-efficacy.

Finally, another study examined the relation between science self-efficacy, active learning, academic performance, and sense of social belonging (Ballen, Wieman, Salehi, Searle & Zamudio, 2017). Participants included students in an introductory biology and biodiversity course at Cornell University in the fall of 2014 and 2015. The sample consisted of majority female and first-year students, and approximately 23% underrepresented minority students (URM). Self-efficacy was measured using modified questions from an instrument developed by Robnett and colleagues (2015), in which students rated their confidence in their ability to do tasks relevant to the course. Cronbach's α was reported to be greater than 0.7. Utilizing general linear analysis, they found that for URM students, science self-efficacy mediated the relationship between active learning and course academic performance.

Summary. The evidence presented suggests that science self-efficacy may function as an important mediator in various relations between student factors and academic outcomes, as well as their intention to pursue a career in research. As the current study included both science self-efficacy and science identity, the next section summarizes findings of the patterns of relation between these two psychosocial indicators.

Relationship between Science Self-Efficacy and Science Identity

Science self-efficacy and science identity have been found to be related in a number of qualitative studies (e.g., Margolis et al., 2000) and several quantitative studies. The results of one quantitative study detailed previously in this review indicated that when both self-efficacy and science identity are considered in the same model, science identity is the primary mechanism through which URM students choose a science occupation (Stets, Brenner, Burke & Serpe, 2017). Furthermore, the results suggested that science identity mediates the relation between self-efficacy and science occupation.

Conversely, results of another study (White, De Cuir-Gunby & Kim, 2019) indicated that science self-efficacy is the mediator of the relation between science identity and outcomes like science achievement. Further, science identity explained 16.5% of the variance in science self-efficacy in their sample of African-American STEM students. Similarly, the cross-sectional results of Chemers et al. (2011) support the mediational role of self-efficacy between research experiences and science identity. In a separate longitudinal analysis of this data set, science self-efficacy (measured at time 2) was also found to have a mediating role in the relation between undergraduate research experience (measured at time 1) and science identity (measured at time 3; Robnett, Chemers & Zurbriggen, 2015).

In the latter study, Robnett et al. (2015) also noted that the relationship between science self-efficacy and science identity was bidirectional, as the reverse association was present between the two variables from time 1 to time 2. Likewise, another investigation found a bidirectional relationship between science identity and science self-efficacy (Robinson et al., 2019). Robinson and colleagues' (2019) longitudinal study on the trajectories of science identity development found that increased science academic self-efficacy is related to increased science identity. Such a two-way relationship reflects the cyclical model of persistence in science (Graham et al., 2013). In short, confidence in science then fosters identification with science, which further cultivates one's confidence in science, and so on (Robnett et al., 2015).

Summary. This review demonstrates the importance of both science identity and science self-efficacy to science achievement, science persistence, and science career interest. It also highlights the established relation between science identity and science self-efficacy. There is mixed evidence in quantitative studies about which may be a stronger predictor of science outcomes, and the directionality of their possible mediating roles, but it is well established that there is a relation between science identity and science self-efficacy. In the current study, both variables were analyzed as predictors of STEM graduate entry, and also as potential mediators of the relation between STEM graduate entry and another important component of STEM success: psychological sense of community.

Psychological Sense of Community

The previous two sections provided an overview of science identity and science self-efficacy, respectively, and STEM outcomes research relevant for the current study.

This section investigates the concept of psychological sense of community, its relevance to the Meyerhoff Scholars Program (MSP), and its significance to STEM outcomes.

Theory of Psychological Sense of Community

The need to belong is a fundamental human need and thus is extremely motivating (Baumeister & Leary, 1995). Belonging to a community provides affiliation, power, and affection, and meets important physiological and psychological needs (Nowell & Boyd, 2010). In considering the notion of community, particularly in psychological research, the theory of psychological sense of community is prominent. Psychological sense of community is a theory developed by McMillan and Chavis (1986) that consists of four components: membership, influence, integration and fulfillment of needs, and shared emotional connection.

While the psychological sense of community (PSOC) theory is salient in the field of community psychology, it is important to note that there has been some criticism and evolution. For instance, PSOC is often measured through the Sense of Community Index (SCI), which has been critiqued for being too focused on the feelings of the individual about the community, rather than focusing on the community as a whole (Hill, 1996). Further, notions of PSOC have evolved to also incorporate that someone's sense of community changes over time, and that being a part of a community is not mutually exclusive; he or she can belong to several communities simultaneously (Mahdi, 2018) with respective senses of community within each (Brodsky, 2001). Though there has been some criticism and expansion, the notion of PSOC and its measurement in the current study is guided by the theory put forth by McMillan and Chavis due to the relatively long history of its use in the literature. Each element of PSOC is described in the following section, along with its relation to the Meyerhoff Scholars Program.

Components of Psychological Sense of Community

The first element of psychological sense of community (PSOC), membership, is described as a feeling of belonging to or being a part of an entity (McMillan & Chavis, 1986). There is also the feeling that an individual has a right to belong because of their investment in the community. The idea that some people belong and others do not indicates that there is a division between members and non-members (McMillan & Chavis, 1986). For example, Meyerhoff Scholars are distinct because they complete a selective application and admissions process that includes an interview weekend. After students are offered and accept the invitation to become part of the MSP, they complete an intensive 6-week summer STEM training program, which further introduces them to the expectations of being a Meyerhoff (Stolle-McAllister, Sto. Domingo & Carillo, 2011). During these 6-weeks, Meyerhoffs live together, take classes together, and learn to rely on each other, as they have little contact with those outside of the program.

The second element of PSOC, influence, refers to whether the group matters to the individual and whether the individual matters to the group (McMillan & Chavis, 1986). Stolle-McAllister, Sto. Domingo, and Carillo (2011) in their qualitative study of current and former Meyerhoffs, note that the students form a strong sense of identity as Meyerhoffs. Note only that, but those in the MSP consider themselves family, and refer to each other as brothers and sisters. In this sense, each Meyerhoff is considered to be of immense importance to the group and the group in turn is immensely important to the individual. In many ways there is a sense that no one is to be left behind. Moreover, Meyerhoffs index their responsibility and accountability not only to themselves, but also to their peers, to do the best and be the best that they can be (Maton, Sto. Domingo, Stolle-McAllister, Zimmerman & Hrabowski III, 2009).

The third element of PSOC is integration and fulfillment of needs, or the feeling that the needs of members will be met through group membership (McMillan & Chavis, 1986). McMillan and Chavis further state that this component is reinforcing; that is, being a part of the community is rewarding to members. Among the reinforcers that they posit are the status that one has by being a member, and the competence that other group members have. To illustrate, some Meyerhoffs have stated that they feel a certain prestige by being in the MSP (Stolle-McAllister, Sto. Domingo & Carrillo, 2011), and others have expressed that being in the program surrounds them with other high-achieving students of color, like themselves (Fries-Britt, 2000). Likewise, the shared characteristics and values foster a greater belonging and a sense of community among Meyerhoffs (Whitesell, Mitchell, Kaufman & Spicer, 2006).

The final element of PSOC, shared emotional connection, refers to the "commitment and belief that members have shared and will share history, common places, time together, and similar experiences" (McMillan & Chavis, 1986, p. 9). Some components of shared emotional connection include having frequent, quality contact with each other, and having a shared investment, among other things (McMillan & Chavis, 1986). For MSP members, there is frequent contact not only with their cohort and other Meyerhoffs through program-wide ("family") meetings, trips, and study groups, but also frequent interactions with staff through advising and personal counseling, and faculty, through research experiences (Maton, Sto. Domingo, Stolle-McAllister, Zimmerman & Hrabowski III, 2009; Stolle-McAllister, Sto. Domingo & Carrillo, 2011).

As described previously, the MSP has various components that embody the theory of psychological sense of community, which has been described as a sense of belonging to the community and a relationship with community members (Maton et al., 2016). This program is an example of a STEM intervention that helps to increase students' competence, belonging, sense of identity, and purpose, among other qualities (Casad et al., 2018). The MSP gives students community, which has been posited as a key contributor to success for STEM students (Mondisa & McComb, 2015). These characteristics would be important for all STEM students, but especially for historically underrepresented minority (URM) students and women.

Experiences of URM and Women Students in STEM

Fries-Britt (2017) argued that due to feelings of isolation, stigma, and stereotypes, it takes much more than academic preparation for students of color to navigate STEM fields. She noted that it takes supports and personal relationships to successfully navigate the "chilly" climate of many STEM disciplines. Many women and URM students experience hostile racial climates and lack of integration in their STEM classes, departments, and the STEM field more generally (Hurtado & Carter, 1997). While Strayhorn (2018) emphasized that college students' sense of belonging is key to educational success, Rattan et al. (2018) and others (e.g., Jordan, 2015; Petty, 2014; Tonso, 1999) through qualitative and quantitative methodologies found that sense of belonging in STEM (which is a component of psychological sense of community) is lower in URM and women students than majority students in STEM.

Jordan (2015) designed an intervention to increase URM engineering students' engineering self-efficacy, sense of belonging to engineering, and retention during their first semester. The treatment group watched videos of diverse older engineering students discussing their positive and negative experiences with belonging, and how they overcame obstacles in their pursuit of an engineering degree. Participants watched the videos during the first few weeks of the semester and completed pre- and post-measures of the Longitudinal Assessment of Engineering Self-Efficacy (LAESE; Marra & Bogue, 2006) and Academic Pathways of People Learning Engineering Survey (APPLES; Sheppard et al., 2010). Reliability and validity were not reported for these scales. Results indicated that URM students reported lower sense of belonging than their white peers. Also, although the intervention contributed to mean gains of engineering self-efficacy, it did not contribute to a significant increase overall in sense of belonging for students.

Rattan and colleagues (2018) discussed the stereotypes and barriers that women and URM students encounter in their respective STEM fields. Specific barriers include widespread stereotypes that women and URM students lack the aptitude for STEM fields; such a social identity or stereotype threat can negatively affect their STEM performance. This has drastic impacts upon these students because sense of belonging has been shown to affect their well-being, which then affects their academic motivation and academic achievement (Anderman & Freeman, 2004; Zumbrunn, McKim, Buhs & Hawley, 2014). These negative racial climates can also influence persistence in STEM (Museus, Nichols & Lambert, 2008). In particular, such experiences play a key role in women and URM students leaving STEM fields (Wilson et al., 2015). A selection of studies related to psychological sense of community will be detailed in the next section.

Psychological Sense of Community and STEM Success

There is limited literature focused on how psychological sense of community for URM STEM students is directly related to STEM achievement, especially as defined in the current study (e.g., matriculation into STEM graduate programs). Thus, the current study has the potential to increase understanding of the important relationship between these variables. Although literature is lacking on the relationship between psychological sense of community and STEM graduate school entry, there are studies that link this construct or related ones (i.e., sense of belonging) to academic outcomes such as GPA and persistence for both non-STEM and STEM students.

Psychological Sense of Community and Non-STEM Student Outcomes

Zumbrunn, McKim, Buhs and Hawley (2014) conducted a cross-sectional mixed methods study to understand how perceptions of belonging, academic motivation, and engagement mediate the relation between academic context and academic achievement. A sample ($n = 212$) of students from various majors enrolled in psychology classes at a mid-western university, and completed surveys that include the Psychological Sense of School Membership Scale (PSSM; Goodenow, 1993). Cronbach's α for this measure was reported to be 0.90. Through structural equation modeling, Zumbrunn and colleagues (2014) found that supportive environments (particularly classroom environments) influenced students' belonging beliefs, which predicted achievement in the course. Qualitative results also supported these findings, as participants shared how peer and instructor acceptance and support were directly related to their sense of belonging.

Ash and Schreiner (2016) focused their efforts on exploring the predictors of success, conceptualized as intent to graduate, among 1,536 ethnic minority students who attend Christian colleges and universities. These students completed surveys about their experiences at twelve colleges/universities nationally. This cross-sectional study found that thriving intellectually, socially, and psychologically, in addition to institutional fit and institutional commitment to student welfare, were direct contributions to intent to graduate, while sense of community had a large, indirect effect on the relation between institutional fit, thriving intellectually, and intent to graduate. The authors used a measure called the Thriving Quotient (Schreiner, 2012; Cronbach's α=0.85), which included a psychological sense of community scale. A limitation of this study, however, in view of the focus of the current study is that the sample was only approximately 34% URM.

Another investigation involved sense of belonging to the university as a predictor of persistence in college (Hausmann, Schofield & Woods, 2007). Hausmann and colleagues developed an intervention to increase sense of belonging for first-year students at a large, predominantly white institution in the mid-Atlantic region. All African-American students (n=254) and white students (n=291) were randomly assigned to the treatment group designed to increase sense of belonging, or to two control groups. Students in the treatment group received electronic messages from the provost that indicated that the students were a valuable part of the campus community. In addition, they received university paraphernalia as gifts to accentuate their connection to the university. Students in one of the control groups also received communication, but rather than messages from university leadership, they received messages from psychology department faculty. These communications did not include wording about "community" and how much the student was valued, but they did receive gifts, albeit general gifts that did not have the university's name or symbolism. The second control group did not receive communication or gifts.

Given the 3-wave, longitudinal structure of the study, Hausmann and colleagues (2007) utilized hierarchical linear modeling, specifically growth curve modeling, to understand how intention to persist and sense of belonging changed over time across both groups. Students who were in the condition that received messages and gifts regarding their value to the school experienced slower declines in sense of belonging than the control groups. Furthermore, for African-American students in the intervention, more peer support was associated with increases in sense of belonging over time. Additionally, the analyses revealed that both peer and parent support were vitally important for persistence in STEM for African-American students. More generally, the findings indicate that feelings of connection are related to intent to persist in college.

Psychological Sense of Community and STEM Student Outcomes

Researchers have found that greater belonging is needed to overcome "chilly" STEM environments, and is related to higher grade point averages for women STEM students (Walton, Logel, Peach, Spencer & Zanna, 2015) and higher science aspirations for ethnic minority high school students (Grossman & Porsche, 2014). Additionally, Cheryan and Plaut (2010) found that sense of belonging to a STEM major (computer science) positively influenced women's pursuit of this major. Through a correlational study, Solanki, McPartlan, Xu and Sato (2019) investigated factors in the achievement of STEM students, and found that students, especially students of color, who are in STEM learning communities experience greater sense of belonging at the end of their first semester. It is possible that STEM achievement interventions such as the Meyerhoff

Scholars Program fill a key role in supporting the achievement of URM STEM students because of integration, membership, and shared emotional connection, among other characteristics.

Two interventions developed by Walton, Logel, Peach, Spencer, and Zanna (2015) also sought to attenuate the effects of “chilly climates,” with particular emphasis on the experiences of women in engineering. The two interventions targeted “social-belonging” and “affirmation-training,” each designed to maintain participants’ sense of belonging to engineering, and manage the stress that comes about through social marginalization, respectively. First year students (N = 228) at the University of Waterloo over three successive cohorts were randomly assigned to one of two treatment groups or two control groups. There were 92 women and 136 men who completed the pre-intervention survey in the first 3 months of classes. All of the women were invited to continue in the study, and the men who matched women based on major and ethnicity were randomly selected to continue participating. Overall, the sample was approximately 38% white, 34% East Asian, 20% South Asian and Middle Eastern, and 8% other or unknown. Belonging was measured using items developed by Walton and Cohen (2011), such as “I belong in engineering at UW.” Cronbach’s α was reported to be 0.64 for the entire scale.

For the interventions, students in each condition were told that researchers previously conducted a survey of upper-class students’ first year experiences in engineering, participants were given a one-page “summary of results,” listened to audio-recordings of students who were said to have participated previously, and participants simultaneously viewed information about the student speaking, as well as pictures of the campus engineering buildings. The social-belonging intervention endorsed that both men and women worried about their belonging in engineering at first, but the worries diminished with time, while the affirmation-training intervention emphasized that men and women upper-class students learned to find balance and manage stress through activities such as "spending time with friends" and "taking mental 'time outs.'" The control group had the same procedure, but the topic was study skills. Both the control and treatment group had a writing activity to facilitate internalization of the messaging. Through multiple regression analyses, Walton et al. (2015) found that the interventions increased women's sense of belonging to engineering, increased their ability to manage daily adversity, and improved their academic attitudes. Moreover, both interventions improved their engineering GPA over the academic year.

A recent qualitative study investigated STEM students' sense of belonging and retention in their STEM major. Rainey, Dancy, Mickelson, Stearns and Moller (2018) interviewed 201 current or former STEM majors (52% URM students) at a public university in North Carolina about key factors in their decision to retain their major. Rainey and colleagues found that white men were more likely to report feeling a strong sense of belonging to their major, while students of color, particularly women of color, felt the least sense of belonging. URM students expressed that their decreased feelings of belonging were influenced by the lack of representation and lack of interpersonal relationships with peers and faculty in their discipline.

Another study examined the association between levels of belonging (i.e., courses, academic major, and university) and types of behavioral and emotional engagement among undergraduates in STEM (Wilson et al., 2015). Approximately 1500 students from five institutions across the United States participated, including an HBCU, a private/faith-based college, a large research institution, a medium-sized institution, and a small women's college. Participants were all STEM majors and one-third were women, with ethnicities reported to be 50% European-American, 25% Asian/Asian-American, 13% African-American, and 12% other.

Students completed the survey from fall 2010 through fall 2012 primarily through STEM courses or STEM groups. Belonging questions were adapted from the belonging scale (Anderson-Butcher & Conroy, 2002), and assessed how supported and accepted participants felt in their STEM course or major. Their sense of belonging to the university was measured using items from the Collegiate Psychological Sense of Community Scale (PSC; Lounsbury & De Neui, 1996). Cronbach's α reliabilities were strong for both scales, ranging from 0.84 to 0.90. Through multiple regression analyses, results indicated that sense of belonging was positively related to behavioral and emotional engagement of STEM students, which is important because engagement is related to persistence in STEM majors (Wilson et al., 2015).

Summary. For students across all majors the literature shows that experiencing a strong sense of community is a factor in retention and academic achievement. However, for STEM students, and specifically URM and women STEM students, the reviewed literature emphasized that they experience "chilly climates" in their programs that are not conducive to thriving and persisting in STEM fields. Having a sense of community and support are important for all academically talented students, but especially underrepresented students, and increases the likelihood that they will experience STEM academic achievement, retention in STEM majors, and ultimately a STEM career. Few studies, however, focused on sense of community in a STEM intervention program, nor the interrelated importance of science identity, science self-efficacy, and sense of belonging to the success of underrepresented students in STEM.

Current Study: Aims and Hypotheses

Through the review of both empirical and theoretical literature, science identity, science self-efficacy, and sense of community have been shown, through various mechanisms, to be positively related to retention in science majors, science academic achievement, graduation, and intent to pursue a science career, among other outcomes. However, less is known about 1) the relations among these variables and in particular the potential mediating relationships among them; 2) the prospective association between these variables and STEM graduate entry; and 3) the potential moderating influence of gender on these relationships within a high-achieving predominantly URM STEM population. No known studies address all of these areas. This gap in research to date highlights the current study's contribution to the literature.

The current study had three research aims, with related hypotheses. Research Aim 1A explored whether mean levels of science identity, science self-efficacy, and psychological sense of community (PSOC) differed by graduate school entry. As research shows that level of science identity (Vincent-Ruz & Schunn, 2018), science self-efficacy (Zeldin & Pajares, 2000), and sense of community (Solanki, McPartlan, Xu & Sato, 2019) are related to science program and career choice, as well as science achievement, respectively, it was important to understand if there was a difference in levels of these psychosocial variables for students who chose various STEM and non-STEM trajectories.

Science identity, science self-efficacy, and psychological sense of community were assessed in the spring of students' third year of college, prior to the year many Meyerhoffs graduate. Additionally, consistent with previous research (e.g., Maton, Pollard, Weise & Hrabowski III, 2012), professional programs were categorized with STEM Master's programs. It was assumed that students with higher levels on each predictor variable would pursue a higher level of graduate education. There were two main hypotheses related to Aim 1A: 1) Participants who matriculate into STEM Ph.D. and M.D./Ph.D. programs will have a higher mean level of science identity, science self-efficacy, and PSOC than those who enter STEM Master's/professional programs, and those who do not enter STEM graduate programs; and 2) Participants who matriculate into STEM Master's/professional programs will have a higher mean level of science identity, science self-efficacy, and PSOC than those who do not enter STEM graduate programs.

Because the Meyerhoff Scholars Program (MSP) seeks to cultivate and strengthen science identity, as well as science self-efficacy and sense of community, it is important to understand the association between change over time in each of these variables and STEM graduate school entry. Therefore, unlike Aim 1A, Aim 1B investigated the relation between change from students' first assessment of science identity, science self-efficacy, and PSOC (during summer bridge), the assessment during their third year, and entry into graduate school. Furthermore, this aim also explored the independent contributions of these predictors. As with Aim 1A, there were two related hypotheses: 1) Science identity, science self-efficacy, and PSOC are independently and positively related to entry into STEM Ph.D. and M.D./Ph.D. programs (versus all other outcomes);

and 2) Science identity, science self-efficacy, and PSOC are independently and positively related to entry into STEM Master's/professional schools (versus no STEM graduate school).

The second aim of the study was to examine the mediational relations among the significant predictors and entry into a graduate program (STEM Ph.D. and M.D./Ph.D. and STEM Master's/professional programs). One previous study (Maton et al., 2016) found that psychological sense of community (assessed during summer bridge) significantly predicted science identity and science self-efficacy in the spring of the second year. However, McMillan and Chavis (1986) and others (e.g., Obst, Smith & Zinkiewicz, 2002) proposed that feeling a sense of identification is causally prior to developing a psychological sense of community. An important identity factor of STEM training programs like the MSP, is science identity. As the relationships between these variables are not well established in the literature, the second research aim was to test both possible mediational models to determine if one of the two models better fit the data than the other. For model one, psychological sense of community (year 3) was expected to mediate the relationship between science identity (year 1) and STEM graduate entry. It was also expected to mediate the relationship between science self-efficacy and STEM graduate entry. For model two, science identity (year 3) was hypothesized to mediate the relation between psychological sense of community (year 1) and STEM graduate entry. The same was hypothesized for science self-efficacy (year 3), where this variable would mediate the relation between psychological sense of community (year 1) and STEM graduate entry.

As the literature indicates that levels of science identity, science self-efficacy, and psychological sense of community may vary by gender (e.g., Hazari, Sadler & Sonnert, 2013; Rastegar, 2019; Vincent-Ruz & Schunn, 2018), a third aim of the current study was to evaluate whether gender moderates the associations among science identity, science self-efficacy, psychological sense of community, and entry into STEM doctoral programs. Exploratory analyses were conducted related to the third research aim. These analyses were conducted with the model from Aim 2 that best fit the data.

Method

Participants

Participants in the current study were students who entered the Meyerhoff Scholars Program (MSP) at the University of Maryland, Baltimore County (UMBC) in the summers of 2014, 2015, and 2016. The MSP was established to increase the numbers of academically under-represented racial and ethnic minority individuals in science, technology, engineering, and mathematics (STEM). Although initially developed for African-American students, it opened to students of all backgrounds beginning in 1996; however, the majority of students continue to be underrepresented ethnic minority students. All students in this study entered UMBC as freshmen pursuing STEM majors full-time.

Students who identify as African-American/Black, Hispanic/Latino, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander are considered URM in STEM. Black students comprised 61.0% of the sample (n = 105), 16.9% were white (n = 29), 11.0% were Asian (n = 19), 9.3% were Hispanic (n = 16), 1.2% were multiracial (African-American/white), and 0.6% of the sample identified as American Indian (n = 1).

Approximately 59.3% of participants indicated they were male, and 40.7% indicated female. Finally, across the three cohorts, there was roughly an equal distribution of students. There were 61 students in cohort 1 (entered fall 2014), 55 students in cohort 2 (entered fall 2015), and 57 students in cohort 3 (entered fall 2016), for a total of 173 students who were potentially eligible for inclusion in the study.

Procedure

Survey data were collected for each cohort of students during their summer bridge programs, and again each spring that they were enrolled at UMBC. The Meyerhoff Scholars Program (MSP) requires that students attend a 6-week intensive STEM training called Summer Bridge the summer prior to their first year. During Summer Bridge, students receive orientation, learn about Meyerhoff program values, cultivate study skills, participate in summer classes, and bond with their cohort prior to beginning their first semester at UMBC. During the academic year, the multi-component MSP also consists of full financial support (tuition and room/board), study groups, tutoring, advising/counseling, field trips, networking opportunities, research experiences and internships, community service, graduate entrance exam preparation, and overall community of current and former Meyerhoff Scholars.

During the summer bridge program, Scholars complete four online surveys in a large computer lab at UMBC. The four survey administrations occur at weekly or biweekly intervals during the 6-week program, and students are allotted approximately 80 minutes to complete them. Before completing surveys, it is confirmed whether students have written informed consent on file. If they do not, they complete the consent process at that time (see Appendix A). Students are informed that the self-report measures are used to conduct on-going assessment of the program. Psychology graduate research assistants and undergraduate research assistants administer the surveys and are available to answer questions during the entire survey administration.

Spring surveys are administered online by the Meyerhoff evaluation research team, sent to Meyerhoff students via e-mail in approximately mid-April of each year and closed before the middle of May. Reminders are sent to students, and MSP staff members encourage survey completion.

Measures

All measures are considered to be reliable and valid, and have been used in numerous studies focused on science identity, science self-efficacy, and psychological sense of community (e.g., Estrada, Hernandez & Schultz, 2018; Maton et al., 2016; Robinson, Perez, Nuttall, Roseth & Linnenbrink-Garcia, 2018). Reliability data are provided below.

Science identity. Science identity was assessed using the 5-item Scientific Identity Scale (Chemers et al., 2010; see Appendix B) that asks students to assess how much being a scientist is perceived as part of who they are. Scale scores were calculated through the mean of all completed items. Reliability of this measure is high, with Cronbach's alpha reported to be 0.86 (Estrada et al., 2011). Sample items include: "I have a strong sense of belonging to the community of scientists," "I have come to think of myself as a 'scientist'," and "The daily work of a scientist is appealing to me."

Science self-efficacy. Science self-efficacy was assessed using seven items from the Scientific Self-Efficacy Scale (Chemers et al., 2010; see Appendix C). This measure assesses students' confidence in their ability to function as a scientist. Scale scores were calculated through the mean of all completed items. A high reliability was reported in prior studies (alpha 0.94; Chemers et al., 2010). Sample items include an individual's confidence in their ability to "Generate a research question to answer," "Develop theories by integrating and coordinating results from multiple studies," and "Create explanations for the results of the study."

Sense of community. Sense of Community within the Meyerhoff Program was measured using 12 items adapted from Chavis and colleagues' (2008) revised Sense of Community Index (SCI-2; see Appendix D). This measure was based on the theory of psychological sense of community (McMillan & Chavis, 1986). Students are asked to report how well each of the twelve statements represent their experience in the program on a 1-4 scale, where 1 corresponds to "Not at all" and 4 corresponds to "Completely." Scale scores were calculated through the mean of all completed items. Reliability of this measure is high, with Cronbach's alpha between 0.82 (Maton et al., 2016) and 0.94 (Chavis, Lee & Acosta, 2008). Sample items include: "I can trust people in the program," "I get important needs of mine met because I am part of the Meyerhoff Scholars Program," and "Being a member of the Meyerhoff Scholars Program is part of my identity."

URM Status. Students reported their race/ethnicity as one of the following categories: "American Indian/Alaska Native/Original Peoples of the Americas," "Asian," "Black/African-American," "Hispanic/Latino," "Native Hawaiian/Pacific Islander/Original Peoples," "White," and "Other." For the "Other" category, students could specify their ethnic background(s). Categories were collapsed to form two categories: URM and non-URM. Students who identify as African-American/Black, Hispanic/Latino, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander were categorized as URM.

Gender. Students reported their gender as "male" or "female."

High School & Year 3 Grade Point Average and SAT Math Score. High school GPA (weighted), year 3 GPA and standardized test information were obtained from the Meyerhoff Program and the UMBC registrar.

Graduate School Status. Graduate school entry status was obtained from Meyerhoff records, and confirmed through internet searches (i.e., university, social media, and professional websites) and the National Student Clearinghouse records. Graduate school status was coded into three categories: STEM Ph.D. and M.D./Ph.D., STEM Master's/professional programs (e.g., Medical School, Pharmacy, Physician's Assistant, etc.), and no STEM graduate school. For Pearson-product moment correlations, *T*-tests, and regression analyses, these categories were collapsed into two categories (e.g., STEM Ph.D. and M.D./Ph.D. and (all) non-Ph.D.).

Results

Preliminary Analyses

The data were screened for missing and out of range values. One case was not included, as this individual did not complete surveys during summer bridge, and did not subsequently enroll in UMBC. Missing data were found for one of the five covariates, year three GPA. Data for year three GPA were missing for 8.7% (missing n = 15) of the sample (See Appendix E, Table E-1). Data were analyzed for patterns of missingness. The data were found to be missing completely at random, as the Little's Missing Completely at Random (MCAR) chi-square test statistic was nonsignificant. Data were imputed for these cases through multiple data imputation. There were no missing data for participant cohort, race/ethnicity, gender, high school GPA, or SAT math score.

There were missing data on each of the three baseline (summer bridge) measures, with 5.2% (*n* = 9) missing scale scores for science identity and science self-efficacy, and 7.0% (*n* = 12) missing scale scores for psychological sense of community (see Appendix E, Table E-2). For cases where an individual was missing one or more of these baseline data, but had complete data for at least one other spring survey, the data were imputed to obtain the respective scale score. Data imputations were calculated using the SPSS Multiple Imputation Procedure, which generated five separate data sets with imputed data for study analyses. The post-imputation mean scale score for science identity during summer bridge was 4.01, with a range of 1.80 to 5.00. Science self-efficacy mean scale score was 3.76, with a range of 2.50 to 5.00. Baseline psychological sense of community had a mean scale score of 3.33, and ranged from 1.00 to 4.00.

Additionally, there were missing data on each of the aforementioned variables measured during year one and three (see Appendix E; Table E-2). For cases where an individual was missing one or more of the scale scores for year one or three variables and had complete data for baseline measures and at least one other end of year survey, data were imputed (as detailed previously). Of participants, 14.5% (*n* = 25) and 48.8% (*n* = 84) were missing scale scores for science identity and science self-efficacy, during year 1 and year 3, respectively. Finally, 15% (*n* = 26) and 47.7% (*n* = 82) of scale scores were missing for psychological sense of community at the end of year 1 and year 3, respectively. Year 3 data were missing due to these participants not completing the end of year survey.

For primary study variables, means for pre-imputation and post-imputation were compared. As anticipated, pre-imputation means approximated the post-imputation data (see Appendix E, Table E-3).

For the respective scales of science identity, science self-efficacy, and psychological sense of community, higher mean scores index stronger agreement with the constructs. The average scale scores for year one and year three science identity were 3.94 and 4.02, respectively, with a range of 2.00 to 5.00 on a 5-point scale. Science self-efficacy had mean scale scores of 3.64 and 3.76, for year one and year three, respectively, and ranged from 1.71 (year one) and 2.36 (year three) to 5.00 on a 5-point scale. Psychological sense of community ranged from 1.33 (year one) and 1.08 (year three) to 4.00 on a 4-point scale, and had mean scale scores of 3.03 and 2.75 at year one and year three, respectively.

High school GPA ranged from 2.69 to 4.85, with a mean of 4.08. For SAT math score, the mean was 672, and scores ranged from 460 to 800. The mean year 3 GPA was 3.45, with a range of 1.90 to 4.00.

Post-imputation Pearson product-moment and Spearman rank-ordered correlations for the final sample (N = 172) are listed in Table 1. For Spearman rank-ordered correlations an ordered variable was used (2=PhD or MD/PhD, 1= STEM Master's/professional school, and 0=no STEM graduate school). Gender and SAT math were not associated with science identity, science self-efficacy, or psychological sense of community at either the end of year 1 or the end of year three. SAT math score was significantly positively correlated with Year 3 GPA (r = .37, p <.01). Expectedly, SAT math was also related to high school GPA (r = .19, p <.05). Further, high school GPA was related to year 3 GPA (r = .34, p<.01) and science identity (year 3; r = .24, p<.01).

Psychological sense of community during summer bridge was positively related to science identity (r = .35, p < .01; r = .46, p <.01; r = .35, p < .01) and science self-efficacy (r = .42, p < .01; r = .35, p <.01; r = .40, p < .01) during summer bridge, year one, and year three, respectively. Likewise, as expected, science identity during summer bridge was positively related to psychological sense of community (year 3; r = .19, p <.05), and science self-efficacy during summer bridge (r = .47, p <.01) and at the end of year one (r = .30, p < .01) and year 3 (r = .26, p <.01). Further, higher science self-efficacy during summer bridge was positively associated with higher science identity during year one (r = .44, p <.01) and year three (r = .29, p < .01).

Psychological sense of community during year 1 was positively associated with year 1 and year 3 science identity (r = .62, p <.01; r = .35, p <.01) and science self-efficacy (r = .44, p < .01; r = .43, p < .01), respectively. Also, science identity during year 1 was positively related to year 1 science self-efficacy (r = .63, p <.01), year 3 psychological sense of community (r = .23, p < .01) and year 3 science self-efficacy (r = .48, p < .01), respectively. Further, year 1 science self-efficacy was positively associated with year 3 science identity (r = .40, p <.01).

Finally, year 3 GPA was significantly related to year 3 science identity (r = .23, p <.01). Year 3 psychological sense of community was positively associated with year 3 science identity (r = .43, p <.01) and year 3 science self-efficacy (r = .32, p< .01), respectively. Likewise, science identity during year 3 was positively related to year 3 higher science self-efficacy (r = .62, p <.01). Given the significant association between year three GPA and year 3 science identity, year 3 GPA will be included as a covariate in analyses with this variable.

Both the dichotomous and rank-ordered criterion variable, graduate entry, were significantly associated with several variables. Specifically, SAT math score was positively correlated with both dichotomous graduate entry ($r = .18$, $p < .05$) and rank-ordered graduate entry ($r_s = .21$, $p < .01$). High school GPA was related to rank-ordered graduate entry ($r_s = .16$, $p < .05$). Additionally, analyses revealed a positive relation between year three GPA and both dichotomous ($r = .49$, $p < .01$) and rank-ordered graduate entry ($r_s = .52$, $p < .01$). Contrary to hypotheses, year 1 psychological sense of community ($r = .05$ and $r_s = .06$, ns), science identity ($r = .14$ and $r_s = .11$, ns), and science self-efficacy ($r = .08$ and $r_s = .08$, ns) were not significantly related to either graduate entry variable. As year three GPA and SAT math were significantly related to graduate entry, they will be included as covariates in primary analyses.

As predicted, graduate entry was positively related to psychological sense of community at the end of year 3 ($r = .17$, $p < .05$), science identity at the end of year three ($r = .31$, $p < .01$; $r_s = .28$, $p < .01$), and science self-efficacy at the end of year 3 ($r = .17$, $p < .05$). This aligns with the hypotheses that stronger psychological sense of community, science identity, and science self-efficacy would be predictive of entry into STEM graduate programs.

Finally, analyses also indexed expected relations between variables measured during summer bridge, year 1, and year 3. Specifically, psychological sense of community at summer bridge was positively related to psychological sense of community at year 1 ($r = .51$, $p < .01$) and year 3 ($r = .18$, $p < .05$). Science identity during summer bridge was positively related to science identity during year 1 (r = .47, p <.01) and year 3 (r = .52, p <.01). Similarly, science self-efficacy at summer bridge was positively associated with science self-efficacy at year 1 (r = .60, p <.01) and year 3 (r = .55, p <.01). Finally, the dichotomous and ordered graduate entry variables were very highly correlated (r_s = .97).

Table 1.
Post-Imputation Correlations for Study Variables (N=172)

	Gender[a] (f)	SAT Math	HS GPA	SOCsb[b]	SIDsb[c]	SSEsb[d]	SOCy1[e]	SIDy1[f]	SSEy1[g]	Y3GPA[h]	SOCy3[i]	SIDy3[j]	SSEy3[k]	Grad Entry[l]	Grad Entry[m]
Gender	-														
SAT Math	-.17*	-													
HS GPA	.09	.19*	-												
SOCsb	.09	.04	-.05	-											
SIDsb	-.09	.05	.05	.35**	-										
SSEsb	-.08	-.02	-.01	.42**	.47**	-									
SOCy1	.12	-.03	.06	.51**	.25**	.35**	-								
SIDy1	-.06	.06	.08	.46**	.47**	.44**	.62**	-							
SSEy1	-.11	.10	.02	.35**	.30**	.60**	.44**	.63**	-						
Y3GPA	.001	.37**	.34**	-.01	.04	.02	.07	.14	.11	-					
SOCy3	.10	-.05	.13	.18*	.19*	.07	.36**	.23**	-.03	.03	-				
SIDy3	.05	.07	.24**	.35**	.52**	.29**	.35**	.64**	.40**	.23**	.43**	-			
SSEy3	.05	.04	.16	.40**	.26**	.55**	.43**	.48**	.52**	.13	.32**	.62**	-		
Grad Entry[i]	.08	.18*	.08	.06	.11	-.004	.05	.14	.08	.49**	.17*	.31**	.17*	-	
Grad Entry[m]	.10	.21**	.16*	.03	.08	-.05	.06	.11	.08	.52**	.11	.28**	.14	.97	-

*p <.05; **$p \leq .01$

a. Gender is coded 0 = *male* and 1 = *female*
b. SOCsb = Psychological Sense of Community during Summer Bridge
c. SIDsb = Science Identity during Summer Bridge
d. SSEsb = Science Self Efficacy during Summer Bridge
e. SOCy1 = Psychological Sense of Community at end of year 1
f. SIDy1 = Science Identity at end of year 1
g. SSEy1 = Science Self Efficacy at end of year 1
h. Year 3 GPA
i. SOCy3 = Psychological Sense of Community at end of year 3
j. SIDy3 = Science Identity at end of year 3
k. SSEy3 = Science Self Efficacy at end of year 3
l. Pearson Correlation: Two categories: PhD, MD/PhD and No STEM PhD
m. Spearman's rank-order correlation: Three categories: PhD, MD/PhD; STEM Master's/professional programs; No STEM graduate school

Analysis of variance results indicated a statistically significant relation between graduate entry and science identity during year three (F (2, 169) = 2.55, $p < .01$, see Table 2). Students who entered STEM doctoral programs reported significantly higher levels of science identity (M = 4.19, SD = .55) than those who did not enter STEM graduate programs (M = 3.85, SD = .50). There were no statistically significant differences between graduate entry and science identity at summer bridge or at year 1. Finally, there were no significant relations between graduate entry and science self-efficacy (see Appendix F, Table F-1), and graduate entry and psychological sense of community (see Appendix F, Table F-2) at summer bridge, year 1, or year 3.

Table 2.

Post-Imputation Analysis of Variance for Science Identity during Summer Bridge, Year 1, and Year 3 by Graduate Entry

Graduate Entry	SCIIDsb[a] Pooled *Mean*	SCIIDy1[b] Pooled *Mean*	SCIIDy3[c] Pooled *Mean*
PhD and MD/PhD (n = 85)	4.08 (.57)	4.02 (.61)	4.19 (.55)[a]
MS, MD, Professional Programs (n = 15)	3.87 (.77)	3.75 (.74)	3.81 (.58)
Non-STEM (n = 72) *No STEM graduate school	3.96 (.59)	3.87 (.55)	3.85 (.50)[b]

F-statistic significant at .01 *p*-level.
Means with different superscripts differ significantly.
a. Science identity during summer bridge
b. Science identity during first year
c. Science identity during third year

Results of analysis of variance also indexed a statistically significant relation between science identity and race/ethnicity during summer bridge (F (2, 169) = 6.27, $p <.01$) and during year three (F (2, 169) = 3.50, $p < .05$; see Table 3). Specifically, URM students reported lower science identity during summer bridge (*M* = 3.91, *SD* = .61) than White (*M* = 4.26, *SD* = .51) and Asian (*M* = 4.28, *SD* = .58) students. There was no significant difference in science identity between White and Asian students. There was no statistically significant difference between science identity and race/ethnicity during year 1 (F (2, 169) = 3.33, $p > .05$). During year three, Asian students experienced higher levels of science identity (*M* = 4.28, *SD* = .49) than URM students (*M* = 3.94, *SD* = .66). URM and White students, and Asian and White students had no difference in science identity during year three, respectively. Because there were no significant differences between white and Asian students in the primary study variables, these two groups were combined for primary analyses. Additionally, as science identity and URM status are significantly related, this was a covariate in analyses that included this variable. In contrast, there were no significant relations between race/ethnicity and either science self-efficacy (see Appendix F, Table F-6) or psychological sense of community (see Appendix F, Table F-7) at any timepoint.

Table 3.

Post-Imputation Analysis of Variance for Science Identity during Summer Bridge, Year 1, and Year 3 by Race/Ethnicity

Race/Ethnicity	SIIDsb[a] Pooled *Mean*	SIIDy1[b] Pooled *Mean*	SIIDy3[c] Pooled *Mean*
URM (n = 124)	3.91 (.61) ^{a}	3.86 (.62)	3.94 (.66)^{a}
Asian (n = 19)	4.28 (.58) ^{b}	4.19 (.60)	4.28 (.49)^{b}
White (n = 29)	4.26 (.51) ^{b}	4.08 (.53)	4.17 (.55)

F-statistic significant at .01 and .05 *p*-level, respectively for SIIDsb and SIIDy3
Means with different superscripts differ significantly.
a. SIIDsb = Science identity during summer bridge
b. SIIDy1 = Science identity during first year
c. SIIDy3 = Science identity during third year

Cross tabulations revealed a statistically significant relation between cohort and STEM graduate entry (χ^2 (4, N = 172) = 14.04, $p < .01$). Of the MSP students who matriculated into UMBC in 2014 (cohort 1), approximately 64% have entered STEM PhD programs, whereas approximately 53% and 30% of students entered STEM PhD programs in cohorts 2 and 3, respectively. Similarly, 33% of those in cohort 1 matriculated into STEM MS and professional programs; however, from cohorts 2 and 3, 7.3% and 10.7% of students entered these programs, respectively. Conversely, most MSP students (58.9%) who matriculated into UMBC in 2016 (cohort 3) and 40% of students in cohort 2 have not entered STEM graduate programs. These results indicate that students in the earliest cohort (cohort 1) are most likely to have pursued STEM graduate studies and those in cohort 3 least likely to do so. As cohort was significantly associated with STEM graduate entry, it was retained as a covariate in the primary analyses.

Table 4.

Pre-Imputation Cross Tabulations for Graduate Entry by Cohort

		Cohort			
		1 (M26)	2 (M27)	3 (M28)	Total
Graduate Entry	PhD and MD/PhD	39 (63.9%)	29 (52.7%)	17 (30.4%)	85
	MS & Professional Programs	5 (8.2%)	4 (7.3%)	6 (10.7%)	15
	Non-STEM	17 (27.9%)	22 (40.0%)	33 (58.9%)	72
	Total	61	55	56	172

Pearson chi-square significant at $p < .01$

Finally, t-test results indicated that, as compared to participants who entered into STEM PhD programs (M = 4.19, SD = .55) participants who did not enter STEM PhD programs (M =

3.85, SD = .51) reported significantly lower science identity during year 3, ($t(170) = -4.23$, $p <$ .001). Similarly, they also reported significantly lower science self-efficacy ($t(170) = -2.31$, p <.05) and psychological sense of community ($t(170) = -2.24$, p <.05) during year 3 (see Appendix F, Table F-13). As expected, *t*-test findings demonstrated that students who did not enter STEM PhD programs (M = 3.25, SD = .44) had a significantly lower year 3 GPA than those who entered STEM PhD programs (M = 3.66, SD = .27), $t(170) = -7.25$, $p < .01$.

Primary Analyses

Aim 1A: Mean levels of SI, SSE, PSOC and STEM graduate school entry

Analyses of co-variance (ANCOVAs) were conducted to examine the hypotheses of Aim 1A. Year 3 science identity, science self-efficacy, and PSOC served as criterion variables. The independent variable in each analysis was matriculation into graduate school entry, with three categories: STEM Ph.D. and M.D./Ph.D. programs, STEM master's/M.D./other professional programs, and no STEM graduate school. Covariates included high school GPA, SAT math score, gender, cohort (continuous), and year 3 GPA. URM status was included as a covariate for analyses that included science identity.

The researcher tested the data for the assumptions underlying analysis of covariance prior to running the analyses. Of note, the data met all assumptions, with the exception of the Shapiro-Wilks test for normality ($p < .05$). However, because skewness and kurtosis were within accepted ranges and ANCOVA is robust to violations of normality, the researcher proceeded with the analyses.

There was a significant difference in levels of science identity based on graduate entry, $F(2, 162) = 5.82$, p <.01, partial $\eta^2 = .07$ (see Table 5). A priori contrasts supported the hypothesis that science identity was significantly greater for those who entered STEM PhD and

MD/PhD programs than for those who entered non-PhD STEM programs *(M_{diff} = .44, 95% CI [.07, .80], $p < .05$ and for those did not enter STEM graduate programs (M_{diff} = .27, 95% CI [.02, .52], $p < .05$). There was no significant difference in science identity between STEM Master's/professional students and those who did not enter a STEM graduate program F (1, 78) = 1.54, p > .05, partial η^2 = .02 (M_{diff} = .19, 95% CI [-.11, .49]).

Analyses indicated that hypotheses regarding science self-efficacy were not supported; that is, science self-efficacy did not significantly differ based on graduate entry F(2, 163) = 1.18, p > .05, partial η^2 = .01 (see Table 5). Students who entered STEM doctoral programs did not report significantly higher levels of science self-efficacy than those entering STEM Master's/professional programs (M_{diff} = .22, 95% CI [-.14, .57], p >.05) and those who did not enter STEM graduate school (M_{diff} = .08, 95% CI [-.16, .33], p >.05). Further, contrary to expectation, STEM Master's/professional program entrants did not report higher levels of science self-efficacy than participants who did not enter STEM graduate programs F (1, 79) = .37, p > .05, partial η^2 = .01 (M_{diff} = .09, 95% CI [-.20, .37]).

Likewise, psychological sense of community did not significantly differ for participants based on entry into STEM doctoral programs versus all others [F(2, 163) = 3.44, p >.05, partial η^2 = .04]. Specifically, those who entered STEM PhD and MD/PhD did not report significantly higher sense of community within the Meyerhoff program than those who entered STEM Master's/Professional programs (M_{diff} = .26, 95% CI [.00, .52], p > .05; see Table 5). Furthermore, there was no evidence to support a statistically significant difference in psychological sense of community between those who entered STEM PhD and MD/PhD programs and those who did not enter a STEM graduate program (M_{diff} = .12, 95% CI [-.06, .30], p > .05). Similarly, and contrary to hypotheses, there was also no significant difference in psychological sense of community between students who entered STEM Master's/professional program and those who did not enter STEM graduate programs, (F (1, 79) = .79, p > .05, partial η^2 = .01, (M_{diff} = .10, 95% CI [-.13, .33]).

Table 5.

ANCOVA Observed and Adjusted Means and Variability by Graduate Entry

	SIIDy3		SSEy3		PSOCy3	
Graduate Entry	Observed Mean (SD)	Adjusted Mean (SE)	Observed Mean (SD)	Adjusted Mean (SE)	Observed Mean (SD)	Adjusted Mean (SE)
PhD and MD/PhD (n =85)	4.19 (0.55)	4.17[a] (0.06)	3.85 (0.54)	3.82 (0.06)	2.81 (0.38)	2.82 (0.05)
MS & Professional Programs (n = 15)	3.81 (0.58)	3.73[b] (0.14) CI [.07, .80]	3.63 (0.68)	3.60 (0.13)	2.59 (0.39)	2.56 (0.10)
Non-STEM (n = 72)	3.85 (0.50)	3.90[b] (0.07) CI [.02, .52]	3.67 (0.42)	3.73 (0.07)	2.70 (0.36)	2.70 (0.05)

Note = Results pooled across 5 imputations. Means with superscripts that differ are significantly different from each other. CI is the 95% adjusted confidence interval.
SCIIDy3 = Science Identity at end of year 3
SSEy3 = Science Self Efficacy at end of year 3
PSOCy3 = Psychological Sense of Community at end of year 3

In summary, hypotheses for Aim 1A were partially supported, as STEM doctoral entry was associated with significantly higher levels of science identity than those who entered STEM

Master's/professional programs and those who did not enter STEM graduate programs. However, contrary to hypotheses, there was no significant difference in science identity between Master's/professional students and those who did not enter a STEM graduate program. Likewise, analyses revealed no significant difference in psychological sense of community between those who entered STEM graduate programs (doctoral and master's) and those who did not enter STEM graduate school. Analogous to this result, science self-efficacy did not significantly differ based on graduate entry.

Aim 1B: Change over time in SI, SSE, and PSOC and Graduate Entry

Two sets of hierarchical logistic regression analyses were conducted for year 3 science identity, science self-efficacy, and PSOC, respectively. The criterion variable for the first set of analyses was STEM doctoral entry (versus the two other categories combined). The criterion variable for the second set of analyses was entry into STEM Master's/professional programs (versus no STEM graduate school). Before the analyses, all assumptions underlying logistic regression were tested and met. For each analysis, all relevant covariates (science identity, science self-efficacy, and PSOC assessed during Summer Bridge, high school GPA, SAT math score, gender, cohort, URM status, and year 3 GPA) were entered in the first step, and the predictor variable was entered in the second step.

The first model for science identity included only covariates and was statistically significant, $\chi^2(7) = 74.68$, $p < .001$. Of the seven covariates, four were significant: science identity during summer bridge, cohort, URM status, and year 3 GPA (see Table 6). Analyses indicated that students who reported higher levels of science identity during summer bridge (odds ratio [OR] = 2.12) and students with a higher year 3 GPA (odds ratio [OR] = 78.07) were more likely to enter STEM doctoral programs than not to enter a STEM doctoral program. Also, students in earlier cohorts were significantly more likely to enter STEM doctoral programs than students in cohort 3.   Results also indexed an association between URM status and entry into STEM doctoral programs for the three cohorts in these analyses; URM students had an increased likelihood of entering a STEM doctoral program (odds ratio [OR] = .33) than not entering a STEM doctoral program.

The second model included year 3 science identity in the second step, and was also statistically significant, χ^2 (8) = 80.87, $p < .001$. After the inclusion of year 3 science identity, science identity during summer bridge was no longer a significant predictor of entry into a STEM doctoral program. Higher levels of science identity at the end of year 3 was associated with an increased likelihood of entering a STEM doctoral program (odds ratio [OR] = 3.00; see Table 6). Conversely, science identity was not significantly related to entry into STEM Master's/professional programs (see Table 7).

The first model for science self-efficacy only included covariates and was significant $\chi^2(7) = 70.17$, $p < .001$ (see Table 8). Significant covariates were cohort and year 3 GPA. The second model included year 3 science self-efficacy, and was also significant; however, year 3 science self-efficacy was not a significant predictor of entry into STEM doctoral programs. Similarly, science self-efficacy did not have a significant relation to entry into STEM Master's/professional programs (see Table 9).

Analyses for psychological sense of community included covariates in the first model and was significant $\chi^2(7) = 71.08$, $p < .001$. Significant covariates were cohort and year 3 GPA. Year 3 psychological sense of community was entered in the second step, and likewise, this model was significant $\chi^2(8) = 75.48$, $p < .001$. Results indicated that higher levels of sense of community with the MSP at the end of year 3 was associated with an increased likelihood of entering a STEM doctoral program (odds ratio [OR] = 3.05; see Table 10). Like science identity and science self-efficacy, psychological sense of community was not found to be significantly related to entry into STEM Master's/professional programs (see Table 11).

Table 6.

Logistic Regression: Year 3 Science Identity and STEM Doctoral Entry, Controlling for Science Identity During Summer Bridge

	B	*SE*	Wald	df	Sig	Exp(B)
Step 1						
SAT math	.00	.00	.08	1	.77	1.00
HS GPA	-.14	.62	.05	1	.83	.87
SIIDsb[a]*	.75	.37	4.19	1	.04	2.12
Cohort**	-1.01	.26	15.13	1	<.001	.36
Gender (f)	-.63	.41	2.32	1	.13	.53
URM Status[b]*	-1.12	.54	4.29	1	.04	.33
Year 3 GPA**	4.36	.79	30.49	1	<.001	78.07
Step 2						
SAT math	.00	.00	.22	1	.64	1.00
HS GPA	-.41	.66	.38	1	.54	.67
SIIDsb	.21	.43	.23	1	.63	1.23
Cohort**	-1.00	.27	14.11	1	<.001	.37
Gender	-.59	.42	1.91	1	.17	.56
URM Status*	-1.14	.55	4.22	1	.04	.32
Year 3 GPA**	4.21	.80	27.64	1	<.001	67.50
SIIDy3[c]*	1.10	.46	5.69	1	.02	3.00

*Chi-square significant at $p < .05$. **Chi-square significant at $p < .001$

a. Science identity during summer bridge
b. 1 = non-URM; 0 = URM
c. Year 3 science identity

Table 7.

Logistic Regression: Year 3 Science Identity and Entry into STEM Master's/professional Programs, Controlling for Science Identity During Summer Bridge

	B	*SE*	Wald	df	Sig	Exp(B)
Step 1						
SAT math	.00	.01	.00	1	.98	1.00
HS GPA*	3.04	1.45	4.40	1	.04	20.82
SIIDsb[a]	-.68	.63	1.15	1	.28	.51
Cohort	-.63	.43	2.21	1	.14	.53
Gender (female)	-.42	.68	.38	1	.54	.66
URM Status[b]	.18	.92	.04	1	.85	1.20
Year 3 GPA	1.60	.92	3.01	1	.08	4.93
Step 2						
SAT math	.00	.01	.00	1	.99	1.00
HS GPA*	3.27	1.50	4.80	1	.03	26.24
SIIDsb	-.37	.72	.26	1	.61	.69
Cohort	-.60	.43	1.98	1	.16	.55
Gender	-.51	.69	.55	1	.46	.60
URM Status	.29	.94	.09	1	.76	1.33
Year 3 GPA	1.63	.93	3.11	1	.08	5.11
SIIDy3[c]	-.87	.83	1.11	1	.29	.42

Note: Results pooled across 5 imputations
* $p < .05$. ** $p < .001$

a. Science identity during summer bridge
b. 1 = non-URM; 0 = URM
c. Year 3 science identity

Table 8.

Logistic Regression: Year 3 Science Self Efficacy and STEM Doctoral Entry, Controlling for Self-Efficacy During Summer Bridge

	B	*SE*	Wald	df	Sig	Exp(B)
Step 1						
SAT math	.00	.00	.02	1	.89	1.00
HS GPA	-.18	.59	.09	1	.77	.84
SSEsb[a]	-.04	.33	.01	1	.91	.96
Cohort**	-1.03	.26	15.60	1	<.001	.36
Gender (female)	-.52	.41	1.65	1	.20	.59
URM Status[b]	-.72	.50	2.07	1	.15	.49
Year 3 GPA**	4.16	.76	29.69	1	<.001	64.23

Step 2						
SAT math	.00	.00	.06	1	.81	1.00
HS GPA	-.22	.60	.14	1	.71	.80
SSEsb	-.49	.42	1.34	1	.25	.61
Cohort**	-1.02	.26	14.87	1	<.001	.36
Gender	-.46	.41	1.25	1	.26	.63
URM Status	-.81	.51	2.50	1	.11	.45
Year 3 GPA**	4.09	.77	28.60	1	<.001	59.65
SSEy3[c]	.84	.48	3.08	1	.08	2.30

Note: Results pooled across 5 imputations
* $p < .05$. ** $p < .001$

a. Science self-efficacy during summer bridge
b. 1 = non-URM; 0 = URM
c. Year 3 science self-efficacy

Table 9.

Logistic Regression: Year 3 Science Self Efficacy and Entry into STEM Master's/professional Programs, Controlling for Science Self-Efficacy During Summer Bridge

	B	*SE*	Wald	df	Sig	Exp(B)
Step 1						
SAT math	-.00	.01	.01	1	.92	1.00
High School GPA*	3.04	1.44	4.45	1	.04	20.98
SSEsb[a]	-.63	.60	1.10	1	.30	.54
Cohort	-.60	.42	2.03	1	.16	.55
Gender (female)	-.39	.68	.32	1	.57	.68
URM Status[b]	-.04	.86	.00	1	.96	.96
Year 3 GPA	1.50	.93	2.62	1	.10	4.49
Step 2						
SAT math	-.00	.01	.01	1	.92	1.00
High School GPA*	3.08	1.47	4.40	1	.04	21.85
SSEsb	-.54	.79	.46	1	.50	.58
Cohort	-.59	.42	1.97	1	.16	.56
Gender	-.38	.68	.31	1	.58	.68
URM Status	-.03	.86	.00	1	.97	.97
Year 3 GPA	1.50	.93	2.60	1	.11	4.48
SSEy3[c]	-.14	.84	.03	1	.87	.87

Note: Results pooled across 5 imputations
* $p < .05$. ** $p < .001$

a. Science self-efficacy during summer bridge
b. 1= non-URM; 0 = URM
c. Year 3 science self-efficacy

Table 10.

Logistic Regression: Year 3 Psychological Sense of Community and STEM Doctoral Entry, Controlling for Psychological Sense of Community During Summer Bridge

	B	*SE*	Wald	df	Sig	Exp(B)
Step 1						
SAT math	.00	.00	.02	1	.90	1.00
HS GPA	-.06	.61	.01	1	.92	.94
PSOCsb[a]*	.42	.44	.91	1	.34	1.53
Cohort**	-1.02	.26	15.17	1	<.001	.36
Gender (female)	-.49	.41	1.44	1	.23	.61
URM Status[b]	-.85	.51	2.72	1	.10	.43
Year 3 GPA**	4.22	.77	29.98	1	<.001	67.86
Step 2						
SAT math	.00	.00	.03	1	.85	1.00
HS GPA	-.27	.63	.18	1	.67	.77
PSOCsb	.26	.46	.32	1	.57	1.29
Cohort**	-1.05	.27	15.44	1	<.001	.35
Gender	-.40	.41	.92	1	.34	.67
URM Status	-.75	.53	2.02	1	.16	.48
Year 3 GPA**	4.31	.80	29.68	1	<.001	74.60
PSOCy3[c]*	1.11	.54	4.20	1	.04	3.05

*Chi-square significant at $p < .05$. **Chi-square significant at $p < .001$
a. Psychological sense of community during summer bridge
b. 1 = non-URM; 0 = URM
c. Year 3 psychological sense of community

Table 11.

Logistic Regression: Year 3 Psychological Sense of Community and Entry into STEM Master's/professional Programs, Controlling for Sense of Community During Summer Bridge

	B	*SE*	Wald	df	Sig	Exp(B)

Step 1						
SAT math	.00	.01	.03	1	.85	1.00
High School GPA*	2.88	1.40	4.23	1	.04	17.89
PSOCsb[a]	-.20	.78	.07	1	.80	.82
Cohort	-.58	.42	1.94	1	.16	.56
Gender (female)	-.50	.68	.54	1	.46	.60
URM Status[b]	-.19	.89	.05	1	.83	.83
Year 3 GPA	1.54	.92	2.80	1	.09	4.67
Step 2						
SAT math	.00	.01	.01	1	.93	1.00
High School GPA*	2.97	1.41	4.49	1	.04	19.34
PSOCsb	-.11	.80	.02	1	.90	.90
Cohort	-.55	.42	1.71	1	.19	.58
Gender	-.51	.69	.56	1	.46	.60
URM Status	-.30	.90	.11	1	.74	.74
Year 3 GPA	1.51	.92	2.67	1	.10	4.51
PSOCy3[c]	-.64	.86	.55	1	.46	.53

Note: Results pooled across 5 imputations
* $p < .05$. ** $p < .001$

a. Psychological sense of community during summer bridge
b. 1 = non-URM; 0 = URM
c. Year 3 psychological sense of community

Finally, a hierarchical logistic regression was conducted for year 3 science identity and year 3 psychological sense of community, the two predictor variables that were significantly related to doctoral program entry, to see if when entered together they independently predicted doctoral entry. Covariates included science identity and psychological sense of community (both assessed during summer bridge), high school GPA, SAT math score, gender, year 3 GPA, cohort (continuous), and URM status. STEM doctoral entry (versus all others) was the criterion variable.

The first step of the analysis included only covariates and was significant, $\chi^2(8) = 74.73$, $p < .001$ (see Table 12). Significant covariates were cohort, URM status, and year 3 GPA. Analyses indicated that students with a higher year 3 GPA (odds ratio [OR] = 78.46) were more likely to enter STEM doctoral programs than not to enter a STEM doctoral program. Further, students in earlier cohorts were significantly more likely to enter STEM doctoral programs than students in cohort 3. Additionally, results indicated an association between URM status and entry into STEM doctoral programs, such that URM students had a higher likelihood of entering a STEM doctoral program than not entering a STEM doctoral program (odds ratio [OR] = .32).

The second step of the analysis included year 3 science identity and year 3 psychological sense of community as predictors, and was significant, $\chi^2(10) = 82.27$, $p < .001$ (see Table 12). However, year 3 psychological sense of community was not a significant predictor ($p > .05$) of STEM doctoral entry, and year 3 science identity ($p = .053$) was marginally significant.

Table 12.

Logistic Regression: Year 3 Science Identity and Psychological Sense of Community, and Entry into STEM Doctoral Programs, Controlling for Summer Bridge

	B	*SE*	Wald	df	Sig	Exp(B)
Step 1						
SAT math	.00	.00	.08	1	.78	1.00
HS GPA	-.11	.63	.03	1	.86	.90
SIIDsb	.72	.39	3.43	1	.06	2.06
PSOCsb	.11	.48	.05	1	.82	1.11
Cohort**	-1.01	.26	14.91	1	<.001	.37
Gender (female)	-.62	.42	2.16	1	.14	.54
URM Status[a]*	-1.13	.55	4.33	1	.04	.32
Year 3 GPA**	4.36	.79	30.53	1	<.001	78.46
Step 2						
SAT math	.00	.00	.22	1	.64	1.00
HS GPA	-.53	.68	.59	1	.44	.59
SIIDsb	.25	.45	.30	1	.58	1.28
PSOCsb	-.20	.50	.16	1	.69	.82
Cohort**	-1.02	.27	14.43	1	<.001	.36
Gender	-.55	.43	1.61	1	.20	.58
URM Status	-1.02	.57	3.26	1	.07	.36
Year 3 GPA**	4.28	.82	27.47	1	<.001	72.38
SIIDy3	.98	.58	1.24	1	.05	2.66
PSOCy3	.65	.58	1.24	1	.27	1.92

Note: Results pooled across 5 imputations

* $p < .05$. ** $p < .001$
SIIDsb = Science identity during summer bridge.
PSOCsb = Psychological sense of community during summer bridge.
a. 1 = non-URM; 0 = URM

In summary, hypotheses for Aim 1B were not supported. Specifically, year 3 science self-efficacy and psychological sense of community were not independently and positively related to and predictive of entry into STEM doctoral programs or STEM Master's/professional programs, and year 3 science identity approached significance for predicting STEM doctoral entry. However, when analyzed in separate regressions, year 3 science identity and psychological sense of community were found to be significantly predictive of entry into STEM doctoral programs.

Aim 2: Mediational Relationship among Predictors

The researcher used the SPSS PROCESS macro (Hayes, 2017; Model 4) to conduct a series of regression models to examine the mediational relations among the significant predictors science identity and psychological sense of community, with the criterion variable entry into a STEM doctoral program (dichotomous). Specifically, two models were tested: 1) year 3 psychological sense of community as a mediator between year 1 science identity and STEM doctoral entry and 2) year 3 science identity as a mediator of the relation between year 1 psychological sense of community and STEM doctoral entry. Both models were tested for level and change (summer bridge baseline controlled), parallel to the models for Aim 1A and Aim 1B, respectively. All regression assumptions were tested and met.

In the first regression (level), the proposed mediator, year 3 psychological sense of community was regressed on the proposed predictor, year 1 science identity and covariates: high school GPA, SAT math score, gender, URM status, cohort, and year 3 GPA (see Table 13). Year 3 psychological sense of community was significantly predicted by year 1 science identity (*b* =

.16, $t(7, 164) = 3.29$, $p<.05$). None of the covariates were significant. Regression 1 explained a significant 9.3% of the variance in year 3 psychological sense of community ($R^2 = .093$).

In the second regression, year 3 psychological sense of community was a significant predictor of entry into STEM doctoral programs ($B = 1.09$, SE = .54, $p <.05$). Additionally, covariates year 3 GPA ($B = 4.25$, SE = .79, $p <.001$) and cohort ($B = -1.04$, SE = .27, $p <.001$) were significant predictors of STEM doctoral entry. Regression results indicate that having a higher GPA during year 3, being a member of an earlier cohort, and reporting higher year 3 psychological sense of community were associated with an increased likelihood of entering a STEM doctoral program. However, while year 1 science identity significantly predicted year 3 psychological sense of community, and year 3 psychological sense of community significantly predicted STEM doctoral program entry, results did not indicate a significant indirect effect of science identity on STEM graduate entry (indirect effect = .17, bootstrap SE = .12, 95% CI [-.02, .44]. Consequently, the hypothesis that year 3 psychological sense of community would mediate the relation between year 1 science identity and STEM doctoral entry was not supported.

Table 13.

Summary of PROCESS Analyses of Proposed Mediation of Year 1 Science Identity on STEM Doctoral Entry, with Covariates (Level)

	b	*SE*	*T*	*F*	R-Square	
Regression 1 – DV: PSOCy3*				2.41*	.093	
SIIDy1*	.16	.05	3.29			
SAT math	-.00	.00	-.23			
High School GPA	.14	.08	1.80			
Cohort	-.01	.03	-.14			
Gender (female)	.07	.06	1.17			

URM[a] Year 3 GPA	.11 .00	.07 .08	1.51 -.02			
	B	*SE*	Z	df	LLCI	ULCI
Regression 2 – DV: STEM PhD Entry**						
SIIDy1	.25	.33	.77	8	-.39	.89
SAT math	.00	.00	.26	8	-.01	.01
High School GPA	-.33	.62	-.53	8	-1.54	.88
Cohort**	-1.04	.27	-3.92	8	-1.56	-.52
Gender (female)	.46	.42	1.10	8	-.36	1.28
URM	.75	.52	1.45	8	-.26	1.76
Year 3 GPA**	4.25	.79	5.39	8	2.71	5.80
PSOCy3	1.09	.54	2.01	8	.03	2.16

Note: Results pooled across 5 imputations
$p< .05$*, $p< .001$**

a. 0 = non-URM; 1 = URM
b. Indirect effect = .17, bootstrap SE = .12, 95% CI [-.02, .44]

For the alternate model for level of predictors, year 3 science identity was the proposed mediator, and was regressed on the proposed predictor, year 1 psychological sense of community, and the exogenous variables detailed previously (see Table 14). Science identity was significantly predicted by year 1 psychological sense of community (b = .38, t(7, 164) = 4.40, p<.001), and this first regression explained a significant 20% of the variance in science identity (R^2 = .20). For the second regression, STEM doctoral entry was significantly predicted by year 3 science identity (B = 1.46, SE = .45, p <.05), cohort (B = -1.05, SE = .27, p <.001), and year 3 GPA (B = 4.27, SE = .81, p <.001).

Consistent with the findings that year 1 psychological sense of community was significantly positively related to year 3 science identity which in turn had a significant, positive direct effect on STEM doctoral entry, the indirect effect was significant (indirect effect = .55, bootstrap SE = .27, 95% CI [.19, 1.23]). Thus, there is support for the hypothesis that year 3 science identity mediates the relation between year 1 psychological sense of community and STEM doctoral entry.

Table 14.

Summary of PROCESS Analyses of Proposed Mediation of Year 1 Psychological Sense of Community on STEM Doctoral Entry, with Covariates (Level)

	b	SE	*t*	*F*	R-Square	
Regression 1 – DV: SIIDy3**				5.92**	.20	
PSOCy1**	.38	.09	4.40			
SAT math	-.00	.00	-.58			
High School GPA	.21	.11	1.94			
Cohort	-.04	.05	-.80			
Gender (female)	-.01	.08	-.10			
URM[a]	-.15	.08	-1.00			
Year 3 GPA	.18	.11	1.69			
	B	*SE*	Z	df	LLCI	ULCI
Regression 2 – DV: STEM PhD Entry**						
PSOCy1	-.70	.49	-1.43	8	-1.65	.26
SAT math	.00	.00	.39	8	-.01	.01
High School GPA	-.50	.65	-.76	8	-1.78	.78
Cohort**	-1.05	.27	-3.84	8	-1.59	-.51
Gender (female)	.62	.42	1.47	8	-.21	1.45
URM	1.05	.53	1.98	8	.01	2.10
Year 3 GPA**	4.27	.81	5.28	8	2.68	5.85
SIIDy3*	1.46	.45	3.24	8	.56	2.34

Note: Results pooled across 5 imputations
p< .05*, *p*< .001**

a. 0 = non-URM; 1 = URM
b. Indirect effect = .55, bootstrap SE = .27, 95% CI [.19, 1.23]

In the next regression for Aim 2 (change over time), the proposed mediator year 3 psychological sense of community was regressed on the proposed predictor year 1 science identity and covariates: science identity during summer bridge, psychological sense of community during summer bridge, high school GPA, year 3 GPA, SAT math score, gender, URM status, and cohort. A significant11% of the variance in psychological sense of community was explained (R^2 = .11). There were no significant predictors of year 3 psychological sense of community in this regression. In regression 2, year 3 GPA (*B* = 4.44, SE = .81, *p* <.001) and cohort (*B* = -1.03, SE = .27, *p* <.001) were the only significant predictors of STEM doctoral entry. Thus, there was no support for an indirect effect of year 1 science identity on STEM graduate entry, controlling for science identity and psychological sense of community during summer bridge (indirect effect = .09, bootstrap SE = .10, 95% CI [-.06, .35]; see Table 15).

Table 15.

Summary of PROCESS Analyses of Proposed Mediation of Year 1 Science Identity on STEM Doctoral Entry, with Covariates (Change over time)

	b	*SE*	*t*	*F*	R-Square	
Regression 1 – DV: PSOCy3				3.08*	.16	

SIIDy1	.04	.06	.68			
SAT math	-.00	.00	-.15			
High School GPA	.14	.08	1.77			
Cohort	.01	.03	.19			
Gender (female)	.06	.06	1.01			
URM[a]*	.15	.07	2.01			
Year 3 GPA	-.001	.08	-.02			
SIIDsb	.08	.05	1.47			
PSOCsb	.03	.07	.40			
	B	*SE*	Z	df	LLCI	ULCI
Regression 2 – DV: STEM PhD Entry**						
SIIDy1	-.00	.38	-.00	10	-.75	.74
SAT math	.00	.00	.32	10	-.01	.01
High School GPA	-.29	.65	-.45	10	-1.57	.99
Cohort**	-1.03	.27	-3.87	10	-1.55	-.51
Gender (female)	.53	.43	1.23	10	-.31	1.37
URM	1.01	.56	1.82	10	-.07	2.11
Year 3 GPA**	4.44	.81	5.46	10	2.85	6.04
SIIDsb	.64	.43	1.51	10	-.20	1.48
PSOCsb	-.00	.50	.00	10	-.99	.99
PSOCy3	.99	.55	1.81	10	-.08	2.06

Note: Results pooled across 5 imputations
$p < .05$*, $p < .001$**

a. 0 = non-URM; 1 = URM
b. Indirect effect = .09, bootstrap SE = .10, 95% CI [-.06, .35]

For the alternate model for change over time, year 3 science identity was the proposed mediator and was regressed on the proposed predictor, year 1 psychological sense of community, and the exogenous variables as noted previously. Regression 1 predicted a significant 40% of the variance in science identity (R^2 = .40). Significant predictors of science identity were: year 1 psychological sense of community (b = .17, $t(9, 162)$ = 2.00, p<.05), high school GPA (b = .25, *t*(9, 162) = 2.61, p<.05), year 3 GPA (*b* = .21, *t*(9, 162) = 2.30, *p* <.05), and science identity during summer bridge (*b* = .41, *t*(9, 162) = 6.50, *p*<.001). In regression 2, STEM doctoral entry was significantly predicted by year 3 science identity (*B* = 1.31, SE = .51, *p* <.05), cohort (*B* = -1.05, SE = .27, *p* <.001), URM status (*B* = 1.15, SE = .56, *p* <.05), and year 3 GPA (*B* = 4.34, SE = .82, *p* <.001). Thus, controlling for summer bridge baseline variables, the hypothesis that there would be significant indirect effect of year 1 psychological sense of community on STEM graduate entry was not supported (indirect effect = .23, bootstrap SE = .19, 95% CI [-.01, .71]; see Table 16).

Table 16.

Summary of PROCESS Analyses of Proposed Mediation of Year 1 Psychological Sense of Community on STEM Doctoral Entry, with Covariates (Change over time)

	B	*SE*	*t*	*F*	R-Square	
Regression 1 – DV: SIIDy3**				12.00**	.40	
PSOCy1*	.17	.09	2.00			
SAT math	-.00	.00	-.31			
High School GPA*	.25	.10	2.61			
Cohort	-.03	.04	-.66			
Gender (female)	.05	.07	.63			
URM[a]	.04	.09	.46			
Year 3 GPA*	.21	.09	2.30			
PSOCsb	.14	.09	1.66			
SIIDsb**	.41	.06	6.50			
	B	*SE*	Z	df	LLCI	ULCI

Regression 2 – DV: STEM PhD Entry**						
	-.74	.51	-1.43	10	-1.75	.27
PSOCy1	.00	.00	.39	10	-.01	.01
SAT math	-.43	.68	-.64	10	-1.76	.89
High School GPA	-1.05	.27	-3.82	10	-1.58	-.51
Cohort**	.65	.43	1.50	10	-.20	1.49
Gender (female)	1.15	.56	2.06	10	.04	2.25
URM*	4.34	.82	5.28	10	2.73	5.95
Year 3 GPA**	.07	.54	.13	10	-.98	1.12
PSOCsb	.24	.44	.55	10	-.62	1.10
SIIDsb	1.31	.51	2.58	10	.31	2.31
SIIDy3*						

Note: Results pooled across 5 imputations
p< .05*, *p*< .001**

a. 0 = non-URM; 1 = URM
b. Indirect effect = .23, bootstrap SE = .19, 95% CI [-.01, .71]

To summarize, there was no support for a significant indirect effect of year 1 science identity via year 3 psychological sense of community on entry into STEM doctoral programs. These results held true during analyses for both level of the predictors and change over time. For the second model, there was a significant indirect effect of year 1 psychological sense of community via year 3 science identity on STEM doctoral entry for level, but not change over time (controlling for summer bridge).

Aim 3: Moderating effect of gender

An exploratory goal was to utilize the best fit model from Aim 2 to determine whether gender moderates any significant associations between the hypothesized predictors science identity, science self-efficacy, and psychological sense of community. Year 3 science identity (SIIDy3) was the only variable that significantly predicted entry into a STEM doctoral program, and only for level (not change), and thus this model was the only one of interest.

The researcher utilized the SPSS PROCESS macro (Hayes, 2017; Model 58) to determine whether there was a moderating effect of gender on the indirect effect of year 1 psychological sense of community on STEM doctoral entry through the mediator year 3 science identity. In the first regression, year 3 science identity was first regressed on year 1 psychological sense of community, SAT math, high school GPA, gender, cohort, URM status, and year 3 GPA. The model was significant and year 1 psychological sense of community significantly predicted year 3 science identity ($b = .38$, $p < .001$; see Table 17). With the addition of the interaction of gender and year 1 psychological sense of community to the second step, results did not support a moderated effect of gender X year 1 psychological sense of community on year 3 science identity ($b = -.26$, $p > .05$; see Table 17). In the second regression, STEM doctoral entry was regressed on year 3 science identity and the other covariates and predictors. Cohort, year 3 GPA, and year 3 science identity significantly predicted STEM doctoral entry. With the inclusion of the aforementioned covariates and predictors, as well as the interaction of gender and year 3 science identity in the second step, results demonstrated that there was no support for a moderated effect of gender X year 3 science identity on STEM doctoral entry ($b = -.52$, $p > .05$; see Table 17).

Table 17.
*Summary of Regression Analyses of Interaction between Gender*Year 3 Psychological Sense of Community and Gender*Year 3 Science Identity on STEM Doctoral Entry*

Variable	Regression 1[a] Step 1 DV: SIIDy3			Regression 1[b] Step 2 DV: SIIDy3			Regression 2[c] Step 1 DV: STEM PhD Entry			Regression 2l[d] Step 2 DV: STEM PhD Entry		
	b	*SE*	*T*	*b*	*SE*	*t*	*B*	*SE*	Z	*B*	*SE*	Z
SAT math	-.00	.00	-.58	.00	.00	-.45	.00	.00	.39	.00	.00	.38
HS GPA	.21	.11	1.94	.21	.11	1.89	-.50	.65	-.76	-.50	.66	-.76
Cohort	-.04	.05	-.80	-.04	.05	-.93	-1.05	.27	-3.84** CI [-1.59, -.51]	- 1.04	.28	-3.79** CI [-1.58, -.50]
Gender (female)	-.01	.08	-.10	.77	.54	1.44	.62	.42	1.47	2.72	3.38	.81
URM[e]	-.15	.08	-1.00	-.14	.10	-1.38	1.05	.53	1.98	1.07	.53	2.00
Year 3 GPA	.18	.11	1.69	.19	.11	1.73	4.26	.81	5.28** CI [2.68, 5.85]	4.25	.81	5.27** CI [2.70, 5.83]
PSOCy1	.38	.09	4.40**	.48	.11	1.75**	-.70	.49	-1.43	-.72	.49	-1.46
Gender*PSOCy1				-.26	.17	-1.47						
SIIDy3							1.46	.45	3.24* CI [.56, 2.34]	1.64	.55	3.01 CI [.57, 2.71]
Gender*SIIDy3										-.52	.83	-.63

Note: Results pooled across 5 imputations; $p < .05$*, $p < .001$**

a. t(7, 164) = 5.92, $R^2 = .20$, $p < .001$
b. t(8, 163) = 5.49, $R^2 = .21$, $p < .001$
c. $\chi^2(8) = 82.76$, $p < .001$, Nagelkerke $R^2 = .51$
d. $\chi^2(9) = 83.15$, $p < .001$, Nagelkerke $R^2 = .51$
e. 0 = non-URM; 1 = URM

Discussion

The present study sought to investigate the relation of science identity, science self-efficacy, and psychological sense of community with STEM graduate program entry among students in the Meyerhoff Scholars Program, including a focus on indirect pathways of influence and possible moderating effects of gender. For Aim 1A, it was hypothesized that Meyerhoff Scholars Program (MSP) students who entered STEM doctoral programs would report higher levels of science identity, science self-efficacy, and psychological sense of community than those who did not, and that students who entered Master's/Professional programs would report higher levels on the three predictors than those who did not pursue any graduate study. Aim 1B expanded the investigation and hypothesized that any significant relations found for the three primary study variables would be retained after baseline levels were added to the analysis. Aim 2 sought to determine whether there were any mediational relations among the significant predictors. Finally, Aim 3 explored the extent to which gender moderated any of the significant mediational relationships.

The results provided partial support for Aim 1A, as students who entered STEM doctoral programs reported higher levels of science identity than those who did not. The hypothesis was not supported, however, for science self-efficacy or psychological sense of community. Furthermore, there were not any differences between students who entered Master's/Professional programs and those who did not pursue post-college education for any of the three variables. There was also partial support for Aim 1B; with baseline measures on each predictor added to the analysis, students who entered STEM doctoral programs reported higher levels of both science identity and psychological sense of community. When the two significant predictors were next entered simultaneously into the analysis, science identity approached significance (p=.053), and psychological sense of community was no longer significant. Contrary to hypothesis, science self-efficacy, with baseline levels controlled, did not predict graduate entry.

There was also partial support for Aim 2, as year 3 science identity mediated the relation between year 1 psychological sense of community and STEM doctoral entry. However, when the baseline measures of science identity and psychological sense of community, respectively, were included in the analysis, the indirect effect was no longer significant. There was no support for an indirect pathway of influence from year 1 science identity to year 3 psychological sense of community to graduate entry, either with or without baseline measures included. Finally, there was no support for Aim 3, as gender did not moderate either of the two significant mediational effects. Each result is discussed below, followed by study limitations, future research directions, and implications of the findings.

Aim 1A (Mean levels) and Aim 1B (Change over time) of SI, SSE, PSOC and STEM graduate school entry

The researcher hypothesized that students who entered STEM doctoral programs would report higher mean levels of science identity, science self-efficacy, and psychological sense of community than those who entered STEM Master's/Professional programs as well as those who did not. In turn, it was hypothesized that students who entered STEM Master's/Professional programs would have higher mean levels of these constructs than students who did not enter STEM graduate programs. These hypotheses were based on prior studies that found science identity (e.g., Estrada, Hernandez & Schultz, 2018; Maton et al., 2016), science self-efficacy (e.g., Byars-Winston, et al., 2017), and psychological sense of community (e.g., Mondisa & McComb, 2015) to be important factors in the academic achievement, graduation, and eventual pursuit of a STEM career for underrepresented students in STEM fields.

As hypothesized, those who entered STEM doctoral programs exhibited higher mean levels of year 3 science identity than those who pursued STEM Master's/Professional programs and those who did not enter a STEM graduate program. This finding is consistent with results from a longitudinal, nationwide study of URM STEM students participating in minority STEM training programs funded by NIH (Estrada, Hernandez & Schultz, 2018). Specifically, Estrada et al. found that science identity predicted pursuit of a STEM career (either graduate school or working in STEM) four years after college graduation. Similarly, the results of the current study are consistent with Robinson and colleagues' (2018) investigation where students with "high" and "moderate-high" trajectories for science identity development over their four years of study at a U.S. university were significantly more likely to have a science career or be in a science field after graduation than students with "moderate-low" trajectories. The current findings extend those of previous research in establishing a relation between science identity and matriculation specifically into a STEM doctoral program.

Carlone and Johnson (2007) note that science identity consists of knowing the concepts germane to one's field of study, using the correct tools, and being validated by important others as being a "science person." The Meyerhoff Scholars Program supports these three aspects of science identity through tutoring and peer study groups, structured research experiences, and close relationships with mentors, among other elements. Also, research experiences that are organized, like those of the MSP, have been found to be associated with higher science identity (Eagan et al., 2012). The current study findings suggest that having salient science identification is important for STEM doctoral program entry because it allows a student to persist and be intrinsically motivated to achieve the goal of becoming a research scientist, despite challenges. That is, Meyerhoff scholars with higher levels of science identity are better prepared than those with lower levels of science identity to overcome obstacles they may encounter during college on the journey to STEM doctoral program matriculation, given their greater resolve to become a scientist due to the stronger science professional identity they have developed.

Of note, science identity remained a significant predictor of STEM doctoral program entry after baseline science identity was included in the analysis (Aim 1B). The aforementioned studies did not control for pre-college science identity, a notable limitation. The results of the current study suggest that pre-college science identity is not the decisive factor in STEM doctoral matriculation; rather it is change over time (positive vs. negative) in identity that predicts STEM doctoral program entry or non-entry. This is especially important given that URM students tend to report lower science identity than their white counterparts (e.g., Ceglie, 2011; Alston, Guy & Campbell, 2017), as was the case for URM students at baseline in the current sample. Moreover, the current findings suggest that participation in the MSP builds (or maintains) identification as a scientist over the course of URM students' undergraduate careers, as by year 3 of college the initial difference between URM and non-URM students on science identity was no longer present. This gives further credence that, as posited by expectancy-value theory (Eccles, 2009; Robinson et al., 2018), identities generally, and in this instance science identity specifically, is dynamic, not static – it is responsive to one's environment and experiences. This indexes the important role that STEM achievement programs have in supporting and enhancing the science identity of underrepresented students in STEM.

Science self-efficacy was not related to STEM doctoral entry, either when baseline science self-efficacy was not included (Aim 1A) or when it was included (Aim 1B) in the analysis. As a STEM enrichment program, the Meyerhoff Scholars Program incorporates programming to cultivate and strengthen participants' science self-efficacy. Meyerhoff students are involved in research experiences both inside and outside the classroom throughout their undergraduate careers. The finding that science self-efficacy was not predictive of STEM graduate school suggests that believing that one is effectively able to conduct research and do the work of a scientist may be necessary, but not sufficient, to motivate or move one to pursue a research-based STEM doctoral degree. Perhaps this result indexes that science self-efficacy is more important for persistence in a STEM major and in the intent to pursue STEM fields generally than for pursuing STEM doctoral study specifically. For instance, research has indicated that science self-efficacy is related to persistence in STEM (Lent et al., 2011; Marra et al., 2009), as well as intention to pursue a research career (Adedokun et al., 2013; Byars-Winston & Rogers, 2018; Chemers et al., 2011), and is an important mediator for science achievement (Kirbulut & Uzuntiryaki-Kondakci, 2019).

It is also possible that other psychological variables mediate the relation between science self-efficacy and STEM doctoral program entry. Although not hypothesized and thus not examined in the current study, science identity, for example, may mediate the relation between science self-efficacy and STEM doctoral program entry. Other possible mediating variables include intention to pursue a PhD, or research excitement. Additional research is necessary to examine these and other possible mediating pathways of influence.

Finally, there could be personal or other factors that influence Meyerhoff students with high science self-efficacy to pursue a Master's or professional degree, or a STEM work career after college, rather than enter a STEM doctoral program. For example, although some students may feel that they have research/science skills needed to conduct research, because of personal characteristics or preferences they may prefer to utilize those skills in industry or in healthcare with a STEM Master's or professional degree. Additionally, some STEM students, and perhaps especially URM STEM students, may choose the pathway of a STEM Master's or professional program (e.g., medical school) since they are deemed to be more lucrative or stable, or may offer a shorter route to a career. Finally, it is possible that the science self-efficacy measure captured generic science skills, rather than nuanced, highly advanced skills that would be found to be related to STEM doctoral program matriculation. Future research is necessary to examine the various possible explanations.

Contrary to the Aim 1A hypothesis, year 3 psychological sense of community did not predict graduate entry. On the other hand, consistent with the corresponding Aim 1B hypothesis, with baseline psychological sense of community added to the analysis, as predicted, year 3 psychological sense of community was significantly related to STEM doctoral program entry.

This result demonstrates the importance of positive change in sense of community with the MSP over time, or alternatively, maintaining a high level of community established during Summer Bridge rather than embarking on a downward trajectory. Students whose sense of community grows over the years or whose high initial levels remain stable may especially benefit from the multi-faceted support and continually high expectations from the program related to achievement of the primary program goal of PhD pursuit.

A strong sense of program community is developed, as previously noted, through frequent supportive contact with peers in one's cohort, other Meyerhoff students, and through interactions with Meyerhoff staff. Because of this bonding, Meyerhoff students consider each other family; thus, while an individual member's success is important, so is the success of the collective group. That is, Meyerhoff students feel accountable and responsible to their fellow Meyerhoffs to be the best that they can be (Maton et al., 2009). Walton and colleagues (2015) found that greater belonging helps underrepresented students overcome "chilly" STEM environments and achieve higher grade point averages, and another study found that students of color who are part of a STEM learning community have a greater sense of belonging (Solanki et al., 2019), which is consistently predictive of engagement and persistence in STEM majors (Cheryan & Plaut, 2010; Wilson et al., 2015)--prerequisites for eventual pursuit of a Ph.D.

Although change from baseline to year 3 on sense of community was a significant predictor of doctoral program entry, year 3 sense of community (level) alone was not. The non-significance of year 3 sense of community (level) in the path analysis reflects, in part, the modest magnitude of the zero-order correlation between year 3 sense of community and doctoral program entry (r=.17). It may be that program elements like sense of community at year 3 contribute to doctoral program level indirectly (e.g., via science identity) rather than directly. In contrast, positive change over time on program elements such as sense of community may reflect an upward trajectory in students' program experience that, in contrast to a downward trajectory, may be sufficient to account for greater levels of doctoral program entry. Alternatively, the lack of significance for sense of community at year 3 may also reflect in part the reality that by year 3 Meyerhoff students have developed outside friendships and networks of additional social support. This suggests that while the MSP plays a crucial role in supporting both URM and non-URM students and giving structure at the outset of their undergraduate career (i.e., early exposure to university life, learning and implementing study skills, connecting to other STEM majors, building community, etc.), perceived psychological sense of community at year 3 has a less profound impact than the overall change in sense of community over the first couple of years.

To test whether science identity and psychological sense of community independently and positively predicted matriculation into a STEM doctoral program, the two constructs were entered together into the analysis. Results indicated that psychological sense of community was no longer a significant predictor, and science identity become marginally significant (p=.053). A few factors may explain this result. First, year 3 psychological sense of community and science identity are highly related to each other - correlational analyses showed a strong, positive association. Although their association does not equate to severe multicollinearity (i.e., correlation equal 0.8 or higher), highly correlated predictors may affect the model's ability to estimate the relationship between predictors and criterion variables. Second, the marginal significance of science identity suggests that it has a stronger association with doctoral entry than psychological sense of community (consistent with their respective zero-order correlations with doctoral entry). Third, it may be that the variables have a "sequential" mediation relation, from sense of community to science identity to doctoral entry, which is obscured when entered together in the regression analysis. Further research is warranted to understand the latent processes between science identity and psychological sense of community and STEM Ph.D. pursuit.

Of note, students who pursued master's/professional programs did not differ from students who did not pursue graduate or professional school on any of the three variables of focus, science identity, psychological sense of community and science self-efficacy. One possible reason is that those who did not matriculate into a STEM graduate program were instead taking more time to learn skills in the STEM labor force, pursuing further undergraduate or post-baccalaureate STEM coursework or research, or otherwise preparing for eventual pursuit of a STEM Master's or a professional program with strict entrance guidelines (e.g., Medical School, Dental

School, etc.). In fact, due to its competitive application process and admissions standards, it is not uncommon for STEM students, particularly pre-professional students, to delay applying for a year or more after graduation (Eagan & Newman, 2010). This could especially be likely in a high achieving STEM population such as the Meyerhoff Scholars. On the other hand, it is also possible that the decision not to pursue master's level graduate school or professional education relates to motivational factors such as a desire to enter well-paying STEM positions after college and also positions with a shorter route to a career in STEM.

Aim 2: Mediational Relations between Significant Predictors - Science Identity and Psychological Sense of Community

The second aim of this study was to examine the mediational relationship between science identity, psychological sense of community, and graduate entry. Based on prior literature, the current study specified two models and sought to clarify which might better explain their proposed relations with graduate entry. Utilizing the MSP participants, Maton and colleagues (2016) found that science identity (year 2) was significantly predicted by psychological sense of community (summer bridge). This result informed the current study's exploration of science identity (year 3) as a mediator of the hypothesized relationship between psychological sense of community (year 1) and STEM graduate entry. However, prior research also offered theoretical support for sense of identity being necessarily prior to the development of sense of community (McMillan & Chavis, 1986; Obst, Smith & Zinkiewicz, 2002). Thus, the current study also investigated psychological sense of community (year 3) as a mediator of the hypothesized relationship between science identity (year 1) and STEM graduate entry.

Consistent with hypotheses and with Maton and colleagues' 2016 study, year 1 psychological sense of community significantly predicted year 3 science identity. Likewise, year 3 science identity was predictive of entrance into STEM doctoral programs. There was no direct effect of year 1 psychological sense of community on doctoral entry; hence, results indexed only an indirect influence on STEM doctoral entry via science identity for psychological sense of community. This finding suggests that, although psychological sense of community affects science identity, alone it is not enough to influence STEM doctoral program entry; rather, science identity is a necessary component of the relation. That is, Meyerhoff scholars build sense of community beginning with Summer Bridge and continuing through year 1 and the resulting level of psychological sense of community at the end of year 1 contributes to the development of science identity in year 3.

Development of a psychological sense of community with the MSP is an important contributor to science identity for a few reasons. First, students who feel a higher sense of community with the MSP tend to engage in more of the elements of the program (Maton et al., 2016). With high engagement and participation in various activities, students are then able to receive more benefits from the program (Maton et al., 2016). Specifically, as a comprehensive intervention to increase the numbers of underrepresented minorities in STEM, the MSP offers an array of supports that target the financial, academic, and social needs of students, including comprehensive financial aid, study groups, academic advising, professional development, and social activities, among many other components. Consequently, program theory posits that students who most benefit from programming then grow a stronger science identity (Maton et al., 2016). According to psychological sense of community theory, membership, influence, integration and fulfillment of needs, and shared emotional connection are essential components of community (McMillan & Chavis 1986). As underrepresented STEM students often experience a lack of integration in STEM (Hurtado & Carter, 1997), as well as isolation, stigma, and stereotypes (Fries-Britt, 2017), belonging to a close-knit community of like-minded, high achieving predominately URM students facilitates the development of higher science identity.

However, the indirect effect of psychological sense of community was no longer significant when baseline summer bridge measures were added to the analysis. Year 1 psychological sense of community continues to predict year 3 science identity, and year 3 science identity continues to predict doctoral program entry, but the indirect effect is not of sufficient magnitude to achieve significance (CI -.01, .77).

There are several possible explanations for why the addition of baseline (summer bridge) psychological sense of community to the path model might change a previously significant indirect effect (.55, SE=.27) to one (.23, SE=.19) that no longer achieves significance (the parameter estimate for year 1 psychological sense of community predicting year 3 science identity is halved when baseline psychological sense of community is added to the equation). First, change over time in psychological sense of community from summer bridge to year 1 may not predict change in science identity from year 1 to year 3 because the intervening months between summer bridge and end of year one do not allow sufficient time for substantive change to occur. Second, the type of change that occurs in psychological sense of community from summer bridge to end of year 1 may simply not be meaningfully related to the change that occurs in science identity from year 1 to year 3. Finally, assessment of sense of community the first week of summer bridge may not truly represent a "baseline" on that variable, since it is possible that students do not know each other, or the program staff well enough, to meaningfully assess their psychological sense of community in the program.

Contrary to hypotheses, there was no support for the second model, psychological sense of community (year 3) as a mediator of the relation between science identity (year 1) and STEM doctoral entry. Specifically, there was no direct relation between science identity (year 1) and psychological sense of community (year 3), no support for a direct relation between psychological sense of community and doctoral entry, and no support for science identity (year 1) directly affecting STEM doctoral entry. One explanation for the non-significant indirect effect is the temporal precedence of science identity – it could be that there is too much time between science identity (year 1) and psychological sense of community (year 3), such that its effect on sense of community is attenuated. Or it may be that there are intervening variables through which year 1 science identity influences year 3 psychological sense of community, such as research experience or research excitement, that were not included in the current study. Another explanatory factor may be that, similar to the results of Aim 1, psychological sense of community with the MSP may be important to shorter-term STEM outcomes en route to the doctorate (e.g., persistence in the major, high GPA, etc.), but not directly related to STEM doctoral entry itself.

Aim 3: Moderating effect of gender

The third and final aim of the study was to determine what role, if any, gender has in moderating the proposed mediation of science identity (year 3) on the relation between psychological sense of community (year 1) and graduate entry. Results indicated that there was no evidence to support that gender moderates any significant relations within the overarching mediational model. Namely, gender was not shown to moderate the direct relation between psychological sense of community and science identity, nor the direct relation between science identity and STEM doctoral entry.

Previous research suggests that, due to stereotypes and barriers that women encounter, their perceived sense of belonging to and community within STEM fields may be diminished compared to men, as well as their perceived science identity (Rattan et al., 2018; Tonso, 1999; Ceglie, 2011). This could then lead to impairment in performance and eventually the decision to pursue STEM in fewer numbers (Beasley & Fischer, 2012; Carr & Steele, 2010), in part due to fear of confirming negative stereotypes about their group through their behavior (Casad et al., 2018). This can be especially salient for Black women in STEM, as they must negotiate a gendered racial identity at the intersection of membership in two historically marginalized groups. That is, they encounter obstacles regarding gender image (e.g., the stereotype that women lack STEM abilities and expectation to prioritize family over career) and race (e.g., stereotypes that question their academic prowess;

Grossman & Porche, 2014). In fact, a study by Rainey and colleagues revealed that amongst all STEM majors, women of color reported the least sense of belonging in STEM (2018).

Based on this and related literature, it was expected that the science identity of women Meyerhoff scholars might be even more enhanced by sense of community than the science identity of men, with higher levels of science identity in turn contributing to STEM PhD entry to a greater extent for women than men. One possible explanation for the lack of moderation may be limited variation in psychological sense of community in the current sample among both women and men, thus limiting the potential for differing relations to science identity by gender to emerge. Another explanation is that the moderating effect of gender may be less pronounced due to the intersectional effect of gender and race/ethnicity, or the reality that stereotype threat and additional barriers may be present to a high extent for all URM students, men as well as women, overriding the specific influence of gender. A third possibility is that the multi-faceted support and family-like atmosphere provided by the Meyerhoff program to all students counteracts negative contextual influences equally for all subgroups of students, including women.

Limitations & Future Research

Although this study has many strengths, there are a number of limitations as well. First, with the exception of graduate entry, the primary study variables are all self-report, which introduces the potential for response bias. For example, as the MSP is a STEM intervention program, to some extent students may not accurately report, or may misperceive themselves on psychosocial variables. Second, as a high achieving, predominantly URM STEM population and national model for STEM intervention, the MSP is uniquely situated as a pipeline to the STEM doctorate. Thus, results from this study may have limited generalizability to other STEM programs.

Third, this study utilized pre-collected data, which did not allow the researcher to include additional variables/measures and time points. For example, in the current study, summer bridge was utilized as a proxy for baseline, but the survey administration began after students were already involved in summer bridge for several days. Thus, future research should incorporate the administration of survey measures (e.g., science identity and science self-efficacy) prior to the start of summer bridge.

Fourth, the researcher did not utilize all available data points in the larger data set. Pre-collected data available to the researcher also included psychosocial variables for years two and four. The inclusion of these and any potential future pre-college variables may better illuminate the processes of influence and any relevant pathways of change. Another limitation is that there were substantial data missing for the primary study variables during year 3, which necessitated utilizing the SPSS Multiple Data Imputation procedure.

Fifth, the study was not adequately powered to detect small effects. Consequently, some analyses may have yielded non-significant results, even if there were small effects. Notably, the population of students in the STEM Master's/professional programs category was substantially smaller than that of STEM doctoral programs and no STEM graduate school.

Although it is challenging to definitively establish the direction of causality among predictor and mediator variables, aforementioned limitations may be addressed in future research by 1) utilizing longitudinal data analytic techniques, including growth curve modeling to explore the trends and fluctuation in science identity development; 2) incorporating variables at all four yearly time points and collecting data more than once per year; 3) including qualitative methodology, as this can help to contextualize and clarify questions regarding complex relations among variables and the influence of contextual variations in a more subtle and nuanced manner than quantitative methods alone, and 4) the power to detect effects may be improved through examining hypotheses with a larger number of cohorts.

Future research should also consider broadening the definition of underrepresented minority beyond race/ethnicity alone and investigate the potential impact of socioeconomic status and immigrant status upon the development of science identity, science self-efficacy, and psychological sense of community and STEM graduate entry. Furthermore, given the strong relationship between psychological sense of community and science identity, future empirical research ideally will conduct a factor analysis to determine if there is one underlying explanatory factor (e.g., scientific sense of community), or two factors. Equally important is that there may be unmeasured, yet to be determined variables that may enhance understanding of the pathway to STEM doctoral program matriculation.

Implications

The current investigation is important since it is the first known study to probe the potential relations among science identity, science self-efficacy, and psychological sense of community, and the prospective association between these constructs and doctoral program entry among a high-achieving, predominantly URM STEM population. Prior studies investigated the relation between these variables and persistence in and commitment to STEM, and intention to pursue a STEM major or career; however, these outcome variables may not translate to actual behavior such as graduate school matriculation. While science self-efficacy and psychological sense of community are important aspects of the Meyerhoff Scholars Program (MSP) and have been shown in prior research to be key mechanisms of its success, the current study extends this research to provide evidence that, among these important levers, science identity may be the most proximal and distinguishing factor in students' progression to a STEM doctoral program. As the MSP seeks to recruit high-achieving students and increase the numbers of underrepresented minorities in STEM, the development of and intentional emphasis on cultivating students' identity as a scientist is one that merits further exploration through programmatic development and future research.

Appendix A
Consent Form

Whom to Contact about this study:
Principal Investigator: Kenneth Maton, Ph.D.
Department: Psychology
Telephone number: 410-455-2209

The Success of Talented Students in Science, Technology, Engineering and Mathematics Informed Consent

This is a consent form for participation in a research project. Your participation in this research study is voluntary. It contains important information about this study and what to expect if you decide to participate. Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate.

I. INTRODUCTION/PURPOSE:

I am being asked to participate in a research study of programs that adapt the components of the Meyerhoff Scholars Program at UMBC, a program that support talented STEM students toward academic and career success . The purpose of this study is to assess the implementation of the Chancellor's Science Scholar Program at University of North Carolina at Chapel Hill (UNC-CH) and the Millennium Scholars Program at Pennsylvania State University (Penn State). It will gather data on 1) implementation barriers, 2) implementation facilitating factors, and 3) department-level and university-wide leadership climate, culture, and structural/contextual factors. I am being asked to volunteer because I am either 1) an administrator, faculty, or staff at UNC-CH or Penn State involved in approval, development, and ongoing operation of the program; or 2) a UMBC Meyerhoff Program consultant. My involvement in this study will begin when I agree to participate and will continue until August 31, 2019.

II. PROCEDURES:

As a participant in this study, I will be asked to answer interview or online survey questionnaires. A total of 60 participants will be part of this study. Interviews will either take place at UNC-CH, Penn State, or UMBC (for UMBC Meyerhoff consultants), or will be conducted over the phone. I will be interviewed multiple times between now and August 31, 2019. All interviews will be audiotaped. The identification code of the interviewee will be written on the audiotape. The interviews will be transcribed but only the identification codes (not the actual name) of the interviewees will be used. The data will be downloaded and all participants will be assigned unique codes that will contain no personal identifying information.

III. VOLUNTARY PARTICIPATION

I have been informed that my participation in this research study is voluntary and that I am free to withdraw or discontinue participation at any time. If I withdraw from this research study, I will not be penalized in any way for deciding to stop participating. I have been informed that data collected for this study will be retained by the investigator and analyzed even if I choose to withdraw from the research. If I do choose to withdraw, the investigator and I have discussed my withdrawal and the investigator may use my information up to the time I decide to withdraw.

IV. RISKS AND BENEFITS OF BEING IN THE STUDY:

My participation in this study does not involve any significant risks and I have been informed that my participation in this research will not benefit me personally, but hopefully will be of significant help to universities in developing science scholarship programs, and to the students pursuing science majors.

V. COMPENSATION/COSTS:

My participation in this study will involve no cost to me.

VI. CONFIDENTIALITY:

Any information learned and collected from this study in which I might be identified will remain confidential and will be disclosed ONLY if I give permission. The investigator (s) will attempt to keep my personal information confidential. A code will be placed on the interview transcript, survey and other collected data. Through the use of an identification key, the researcher will be able to link my survey to my identity. Only the researchers will have access to the identification key.

To help protect my confidentiality, all data will be kept in password protected files at the lab of Dr. Kenneth Maton, the Research Director, at UMBC. All printed data or reports will be kept in in Dr. Maton's alarm-secured and locked research lab.

Only the investigator and members of the research team will have access to these records. If information learned from this study is published or included in a report, I will not be identified by name or position. By signing this form, however, I allow the research study investigator to make my records available to the University of Maryland Baltimore County (UMBC) Institutional Review Board (IRB) and regulatory agencies as required to do so by law.

Consenting to participate in this research also indicates my agreement that all information collected from me individually may be used by current and future researchers in such a fashion that my personal identity will be protected. Such use will include sharing anonymous information with other researchers for checking the accuracy of study findings and for future approved research that has the potential for improving human knowledge.

I give permission to record my voice or image and use in scientific publications or presentations.

I do not give permission to record use my voice or image and use in scientific publications or presentations.

VII. SPONSOR OF THE RESEARCH:

HHMI (Howard Hughes Medical Institute) is the sponsor of this research study.

VI. CONTACTS AND QUESTIONS:

The principal investigator, Dr. Kenneth Maton, who is responsible for this research study, has offered to and has answered any and all questions regarding my participation in this research study. If I have any further questions, I can contact Dr. Maton at (410) 455-2209.

If I have any questions about my rights as a participant in this study, I can contact the UMBC Office of Research Protection and Compliance at (410) 455-2737 or compliance@umbc.edu.

I will be given a copy of this consent form to keep.

VII. SIGNATURE FOR CONSENT

By typing my name, email address and date, I agree to be a research participant in this study. I will return the signed form by email to maton@umbc.edu.

Participant's Signature: ____

Email address: ____

Date: _______________________

Investigator's Signature: ____________________________ Date: ________________

Appendix B

Science Identity Scale

The following questions ask how you think about yourself and your personal identity. We want to understand how much you think that being a scientist or engineer is part of who you are. For the purposes of this study when you see the word scientist or engineer it is intended to mean a professional undertaking research activities in your area of study (e.g., a biologist or a research engineer). Please select the best answer on the scale from strongly disagree to strongly agree.

	Strongly Disagree (1)	Disagree (2)	Neither Disagree nor Agree (3)	Agree (4)	Strongly Agree (5)
a. I have a strong sense of belonging to the community of scientists or engineers. (1)	•	•	•	•	•
b. I derive great personal satisfaction from working on a team that is doing important research. (2)	•	•	•	•	•
c. I have come to think of myself as a 'scientist' or ‘engineer.’ (3)	•	•	•	•	•
d. I feel like I belong in the field of science or engineering. (4)	•	•	•	•	•
e. The daily work of a scientist or engineer is appealing to me. (5)	•	•	•	•	•

Appendix C

Science Self-Efficacy Scale

This section assesses your confidence in your abilities to function as a scientist or engineer in your area. Indicate the extent to which you are confident you can successfully complete the following tasks. Please select the best answer on the scale from not at all confident to absolutely confident.

	Not at All Confident (1)	Somewhat Confident (2)	Moderately Confident (3)	Very Confident (4)	Absolutely Confident (5)
a. Use technical science skills (use of tools, instruments, and/or techniques) (1)	•	•	•	•	•
b. Generate a research question to answer (2)	•	•	•	•	•
c. Figure out what data I should collect (3)	•	•	•	•	•
d. Create explanations for the results of the study (4)	•	•	•	•	•
e. Use scientific literature and/or reports to guide research (5)	•	•	•	•	•
f. Develop theories by integrating and coordinating results from multiple studies (6)	•	•	•	•	•
g. Report research results in an oral presentation (7)	•	•	•	•	•

Appendix D

Psychological Sense of Community Scale

How well does each statement represent how you feel about the Meyerhoff Scholars Program?

Not at all	Somewhat	Mostly	Completely

1. I get important needs of mine met because I am part of the Meyerhoff Scholars Program.
2. Program members and I value the same things.
3. When I have a problem, I can talk about it with members of the program.
4. I can trust people in the program.
5. I can recognize most of the members of the program.
6. Most program members know me.
7. Being a member of the Meyerhoff Scholars program is a part of my identity.
8. I have influence over what the program is like.
9. If there is a problem in the program, members can get it solved.
10. I am with the other Meyerhoff Scholars a lot and enjoy being with them.
11. I expect to be a part of the program for a long time.
12. Members of the program care about each other.

Appendix E

Missing Data Analyses and Descriptives for Primary Study Variables

Table E-1.

Missing Data: Potential Covariates

Potential Covariate	Missing *N*	Missing %
Gender	0	0.0
Cohort	0	0.0
Year 3 GPA	15	8.7
High School GPA	0	0.0
SAT Math	0	0.0
Race/Ethnicity	0	0.0

Table E-2.

Missing Data: Summer Bridge and Primary Study Variable Measure Scales

Variable	Missing *N*	Missing %*
SCIIDsb	9	5.2
SSEsb	9	5.2
PSOCsb	12	7.0
SCIIDy1	25	14.5
SSEy1	25	14.5
PSOCy1	26	15.0
SCIIDy3	84	48.8
SSEy3	84	48.8
PSOCy3	82	47.7

*Percentage of missing data at scale level.
SCIIDsb = Science Identity during Summer Bridge
SSEsb = Science Self Efficacy during Summer Bridge
PSOCsb = Psychological Sense of Community during Summer Bridge
SCIIDy1 = Science Identity at end of year 1
SSEy1 = Science Self Efficacy at end of year 1
PSOCy1 = Psychological Sense of Community at end of year 1
SCIIDy3 = Science Identity at end of year 3
SSEy3 = Science Self Efficacy at end of year 3
PSOCy3 = Psychological Sense of Community at end of year 3

Table E-3.

Descriptive Statistics for Continuous Variables: Pre-Imputation (Post-Imputation)

	N	Min	Max	Mean	SD	Scale Range
SCIIDsb	163	1.80	5.00	4.03 (4.01)	0.61	1-5

SSEsb	163	2.50	5.00	3.77 (3.76)	0.58	1-5
PSOCsb	160	1.00	4.00	3.33 (3.33)	0.49	1-4
SCIIDy1	148	2.00	5.00	3.95 (3.94)	0.64	1-5
SSEy1	148	1.71	5.00	3.67 (3.64)	0.65	1-5
PSOCy1	147	1.33	4.00	3.04 (3.03)	0.49	1-4
SCIIDy3	88	2.00	5.00	4.07 (4.02)	0.63	1-5
SSEy3	88	2.36	5.00	3.80 (3.76)	0.56	1-5
PSOCy3	86	1.08	4.00	2.74 (2.75)	0.46	1-4

SCIIDsb = Science Identity during Summer Bridge
SSEsb = Science Self Efficacy during Summer Bridge
PSOCsb = Psychological Sense of Community during Summer Bridge
SCIIDy1 = Science Identity at end of year 1
SSEy1 = Science Self Efficacy at end of year 1
PSOCy1 = Psychological Sense of Community at end of year 1
SCIIDy3 = Science Identity at end of year 3
SSEy3 = Science Self Efficacy at end of year 3
PSOCy3 = Psychological Sense of Community at end of year 3

Table E-4.

Descriptive Statistics for Continuous Covariates: Pre-Imputation (Post-Imputation)

	N	Min	Max	Mean	SD
High School GPA	172	2.69	4.85	4.08	0.40
SAT math score	172	460	800	672	61.2
Year 3 Spring GPA	157	1.90	4.00	3.49 (3.45)	0.40

Appendix F.

Preliminary Results – Analyses of Variance, Cross Tabulations, and *T*-Tests

Table F-1.

Post-Imputation Analysis of Variance for Science Self Efficacy during Summer Bridge, Year 1, and Year 3 by Graduate Entry

Graduate Entry	SSEsb Pooled *Mean*	SSEy1 Pooled *Mean*	SSEy3 Pooled *Mean*
PhD and MD/PhD (n = 85)	3.76 (.58)	3.69 (.63)	3.85 (.54)
MS and Professional Programs (n = 15)	3.61 (.72)	3.58 (.58)	3.63 (.68)
Non-STEM (n = 72)	3.79 (.52)	3.60 (.58)	3.69 (.42)

F-statistic non-significant at .05 *p* level

Table F-2.

Post-Imputation Analysis of Variance for Psychological Sense of Community during Summer Bridge, Year 1, and Year 3 by Graduate Entry

Graduate Entry	PSOCsb Pooled *Mean*	PSOCy1 Pooled *Mean*	PSOCy3 Pooled *Mean*
PhD and MD/PhD (n = 85)	3.36 (.47)	3.06 (.47)	2.81 (.45)
MS and Professional Programs (n = 15)	3.27 (.51)	3.08 (.66)	2.59 (.31)
Non-STEM (n = 72)	3.31 (.52)	2.99 (.42)	2.70 (.48)

F-statistic non-significant at .05 *p* level

Table F-3.

Post-Imputation Analysis of Variance for Science Identity during Summer Bridge, Year 1, and Year 3 by Cohort

Cohort	SIIDsb Pooled *Mean*	SIIDy1 Pooled *Mean*	SIIDy3 Pooled *Mean*
1 (M26; n = 61)	4.02 (.64)	3.96 (.53)	4.05 (.65)

2 (M27; n = 55)	4.03 (.64)	3.94 (.64)	4.04 (.65)
3 (M28; n = 56)	3.99 (.55)	3.90 (.65)	3.96 (.60)

F-statistic non-significant at .05 *p* level

Table F-4.

Post-Imputation Analysis of Variance for Science Self Efficacy during Summer Bridge, Year 1, and Year 3 by Cohort

Cohort	SSEsb Pooled *Mean*	SSEy1 Pooled *Mean*	SSEy3 Pooled *Mean*
1 (M26; n = 61)	3.79 (.60)	3.68 (.61)	3.79 (.65)
2 (M27; n = 55)	3.80 (.58)	3.69 (.63)	3.82 (.56)
3 (M28; n = 56)	3.69 (.55)	3.55 (.63)	3.67 (.55)

F-statistic non-significant at .05 *p* level

Table F-5.

Post-Imputation Analysis of Variance for Psychological Sense of Community during Summer Bridge, Year 1, and Year 3 by Cohort

Cohort	PSOCsb Pooled *Mean*	PSOCy1 Pooled *Mean*	PSOCy3 Pooled *Mean*
1 (M26; n = 61)	3.34 (.44)	3.08 (.44)	2.75 (.50)
2 (M27; n = 55)	3.44 (.45)	3.03 (.46)	2.75 (.38)
3 (M28; n = 56)	3.22 (.56)	2.99 (.50)	2.74 (.48)

F-statistic non-significant at .05 *p* level

Table F-6.

Post-Imputation Analysis of Variance for Science Self Efficacy during Summer Bridge, Year 1, and Year 3 by Race/Ethnicity

Race/Ethnicity	SSEsb Pooled *Mean*	SSEy1 Pooled *Mean*	SSEy3 Pooled *Mean*
URM (n = 124)	3.71 (.60)	3.59 (.62)	3.72 (.60)

Asian (n = 19)	4.02 (.47)	3.87 (.58)	3.86 (.58)
White (n = 29)	3.83 (.50)	3.72 (.41)	3.90 (.57)

F-statistic non-significant at .05 *p* level

Table F-7.

Post-Imputation Analysis of Variance for Psychological Sense of Community during Summer Bridge, Year 1, and Year 3 by Race/Ethnicity

Race/Ethnicity	PSOCsb Pooled *Mean*	PSOCy1 Pooled *Mean*	PSOCy3 Pooled *Mean*
URM (n = 124)	3.28 (.51)	3.01 (.50)	2.76 (.45)
Asian (n = 19)	3.54 (.44)	3.18 (.49)	2.73 (.39)
White (n = 29)	3.41 (.40)	3.03 (.44)	2.71 (.25)

F-statistic non-significant at .05 *p* level

Table F-8.

Pre-Imputation Cross Tabulations for Graduate Entry X Cohort

		Cohort			
		1 (M26)	2 (M27)	3 (M28)	Total
Graduate Entry	PhD and MD/PhD	39 (63.9%)	29 (52.7%)	17 (30.4%)	85
	MS & Professional Programs	5 (33.3%)	4 (7.3%)	6 (10.7%)	15
	Non-STEM	17 (27.9%)	22 (40.0%)	33 (58.9%)	72
	Total	61	55	56	172

Pearson Chi-Square significant at $p < .01$

Table F-9.
Pre-Imputation Cross Tabulations for Graduate Entry X Gender

		Gender		
		Male	Female	Total
Graduate Entry	PhD and MD/PhD	47 (46.1%)	38 (54.3%)	85
	MS & Professional Programs	8 (7.8%)	7 (10.0%)	15

	Non-STEM	47 (46.1%)	25 (35.7%)	72
	Total	102	70	172

Pearson Chi-Square non-significant at p = .05

Table F-10.
Pre-Imputation Cross Tabulations for Graduate Entry X URM Status

		Race/Ethnicity		
		Non-URM	URM	Total
Graduate Entry	PhD and MD/PhD	26 (54.2%)	59 (47.6%)	85
	MS & Professional Programs	6 (12.5%)	9 (7.3%)	15
	Non-STEM	16 (33.3%)	56 (45.2%)	72
	Total	48	124	172

Pearson Chi-Square non-significant at p = .05

Table F-11.
Pre-Imputation Cross Tabulations for URM Status X Gender

		Gender		
		Male	Female	Total
URM Status	Non-URM	30 (29.4%)	18 (25.7%)	48
	URM	72 (70.6%)	52 (74.3%)	15
	Total	102	70	172

Pearson Chi-Square non-significant at p = .05

Table F-12.
Pre-Imputation Cross Tabulations for URM Status X Cohort

		Cohort			
		1 (M26)	2 (M27)	3 (M28)	Total
URM Status	Non-URM	17 (27.9%)	14 (25.5%)	17 (30.4%)	48
	URM	44 (72.1%)	41 (74.5%)	39 (69.6%)	124
	Total	61	55	56	172

Pearson Chi-Square non-significant at p = .05

Table F-13.

Post-Imputation T-Test (Grad Program and Science Identity, Science Self-Efficacy, and Psychological Sense of Community during Summer Bridge, Year 1 and Year 3, and Spring GPA)

	Graduate Entry		*t*-value	*df*	*p*
	PhD and MD/PhD	Non-STEM PhD			
SIIDsb Pooled *Mean* (SD)	4.08 (.57)	3.95 (.62)	-1.45	170	.15
SIIDy1 Pooled *Mean* (SD)	4.02 (.61)	3.85 (.59)	-1.83	170	.07
SIIDy3** Pooled *Mean* (SD)	4.19 (.55)	3.85 (.51)	-4.23	170	<.001**
SSEsb Pooled *Mean* (SD)	3.76 (.56)	3.76 (.58)	.06	170	.96
SSEy1 Pooled *Mean* (SD)	3.70 (.63)	3.59 (.61)	-1.04	170	.30
SSEy3* Pooled *Mean* (SD)	3.85 (.54)	3.68 (.47)	-2.31	170	.02*
PSOCsb Pooled *Mean* (SD)	3.36 (.46)	3.31 (.50)	-.74	170	.46
PSOCy1 Pooled *Mean* (SD)	3.06 (.47)	3.01 (.47)	-.68	170	.50
PSOCy3* Pooled *Mean* (SD)	2.81 (.38)	2.68 (.36)	-2.24	170	.03*
Year 3 GPA** Pooled *Mean* (SD)	3.66 (.27)	3.25 (.44)	-7.25	170	<.001**

**F*-statistic significant at .05 *p* level; ** *F*-statistic significant at .01 *p* level

a. SIIDsb = Science Identity during Summer Bridge
b. SSEsb = Science Self Efficacy during Summer Bridge
c. PSOCsb = Psychological Sense of Community during Summer Bridge
d. SIIDy1 = Science Identity at end of year 1
e. SSEy1 = Science Self Efficacy at end of year 1
f. PSOCy1 = Psychological Sense of Community at end of year 1
g. SIIDy3 = Science Identity at end of year 3
h. SSEy3 = Science Self Efficacy at end of year 3
i. PSOCy3 = Psychological Sense of Community at end of year 3

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