Discovering Pathways to Persistence for Underrepresented Racial Minority Women in STEM: A Comparative Study of Women’s, Historically Black, and Coeducational Liberal Arts Colleges in the United States

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A thesis submitted for the degree of Doctor of Philosophy

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2017
AUTHOR'S DECLARATION

This is to certify that:

I. This thesis comprises only my original work towards the Doctor of Philosophy Degree.

II. Due acknowledgement has been made in the text to all other material used.

III. The thesis does not exceed the word length for this degree.

IV. No part of this work has been used for the award of another degree.

V. This thesis meets the University of Sydney’s Human Research Ethics Committee (HREC) requirements for the conduct of research.

Signature(s)

Name: Deborah Ann Tully

Date: 28 March 2017
Abstract

The low participation rate of university students in STEM fields (science, technology, engineering and mathematics), specifically those from underrepresented minority groups, is an area of national concern in the United States. The U.S. Federal Government has spent more than $1.1 billion to secure a well-trained STEM workforce with a principal aim of focusing upon groups that are underrepresented in STEM. While these efforts have produced increased minority student STEM enrolment, retention results are less impressive. Minority women comprise more than 20% of the U.S. population yet earn less than 10% of STEM degrees. As the American population grows increasingly diverse, the scale of this underrepresentation poses major equity issues. Existing scholarly work points to the need to further understand the undergraduate experience of these women. The purpose of this study is to gain a better grasp of how the organisational environment and social practices experienced at different types of liberal arts colleges affect the persistence of underrepresented racial minority (URM) women in STEM. Drawing on identity theory, a college socialisation impact model, and theories of cultural and social capital, this study aims to offer a comparative analysis of the contributions made by women’s colleges, historically black colleges and universities (HBCUs), and coeducational liberal arts colleges towards promoting persistence for URM women in STEM. Private colleges, in general, exhibit higher retention rates for students in STEM, and graduates from liberal arts colleges are twice as likely to earn a PhD in science when compared to graduates from other baccalaureate granting institutions. The five colleges in this study are all private liberal arts colleges and were purposively selected because they have each demonstrated a proven track record of graduating impressive numbers of women in STEM. Using a mixed-methods research
design, data was collected through questionnaires, semi-structured interviews, formal and informal observations, and document gathering. For comparative analysis purposes, survey data was collected from both URM and non-URM female STEM students ($n=447$). However, interviews were conducted exclusively with URM female STEM students ($n=30$). Both descriptive and inferential statistics were generated from the quantitative data using Chi-Square tests, Mann-Whitney U tests, Kruskal-Wallace tests and Multiple Regression Analysis. Interpretation of qualitative data employed narrative analysis, content analysis, analytic induction and logical analysis. Results indicate that for URM female STEM students, the acquisition of education enhancing capital leading to persistence depends upon their ethnic identity commitment, their belief that their colleges offered effective diversity programs and their sense of academic belonging in STEM during the first two years of study. Science Identity for URM female STEM students was influenced by the acquisition of social capital within STEM networks as well as students’ positive perception of their campus’ racial climate. Additionally, URM female STEM students who persisted beyond their second year of study participated in more extracurricular activities than did their non-URM counterparts, and were almost twice as likely to be in a professional mentoring relationship. Further results highlight the impact of pre-college background, peer, faculty and other influential relationships on persistence, as well as involvement with college-preparation programs, professional clubs and research experiences. Exploring the experiences of successful URM female STEM students may illuminate how future practices and policies can be shaped within the landscape of liberal arts colleges to promote further gains for minority women pursuing a STEM pathway, with an eye towards shaping a more equitable and diversified STEM workforce.
Acknowledgements

While it may appear that completing a PhD thesis is a solo pursuit, there are many supporting players who actually aid and guide the process. First, I would like to thank the University of Sydney for their generous funding which allowed me the privilege of pursuing and completing this PhD research project. I am humbled and grateful. I would also like to thank my thesis advisor, Professor Anthony Welch for his wisdom and mentorship throughout this process. I offer my gratitude to Dr. Alun Pope for his guidance with the statistical analyses in this thesis. For all my faculty collaborators at the five colleges participating in this research, I am deeply appreciative of your sacrifice of time in helping to organise my research visits at your colleges. I would also like to thank my husband Frank who was a constant source of support throughout this process. And Tamica, my PhD buddy, thanks for all the encouragement you offered in our many chats and conversations.

Additionally, I could not have completed this thesis without the learning platforms found on YouTube or the online courses offered through EdX and Coursera. Thank you Google and the founders of and contributors to these MOOCs! You have redefined what it means to be an independent lifelong learner.

Finally, I would like to acknowledge Cassandra Vickers and Minica Long. Thank you for sharing your journeys with me during your high school experience when I was your mathematics teacher and college guidance counsellor. You opened my eyes to the challenges that young women of colour face in their pursuit of following a dream towards a science career. The obstacles you needed to overcome were invisible to so many around you, yet you persevered. Thank you for your transparency, allowing me a window into your world. I am so proud that you have each finished college and are on
the path towards reaching your career goals. Cassandra, I know you left your mark at
the University of Pennsylvania. And Minica, with a degree from Williams College and
now the journey of medical school before you, I stand in awe! Thank you again for
enriching my life with your stories! I dedicate this thesis to both of you.
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Chapter 1: Introduction

In the United States, the development of a talented and innovative science, technology, engineering and mathematics (STEM) workforce is critical to remaining competitive in today’s global economy and worldwide marketplace (Chen & Soldner, 2013). However, of increasing national concern is the low participation rate of American university students in STEM fields, specifically those from underrepresented minority groups (Landivar, 2013). In recent years, less than one out of every ten STEM undergraduate degrees in the United States has been awarded to a woman of colour (NSF, 2013). The National Science and Technology Council (2012) reveals that the U.S. Federal Government has spent more than $1.1 billion to secure a well-trained STEM workforce with “the primary goal of targeting groups that are underrepresented in STEM” (p. 9). While these efforts have produced increased minority student STEM enrolment, retention results are less impressive with only one out of five Hispanic, African American and Native American students actually persisting to graduation in a STEM field (HERI, 2010). In 2010, approximately 22% of STEM bachelor’s degrees in the U.S. were earned by underrepresented minority students (NSF, 2013). These percentages pale in comparison to the ethnic and racial composition of the United States’ population. The U.S. Census Bureau (2012) projected that in 2015, minorities would account for over 33% of the population. By 2044, it is projected that more than half of the total U.S. population will be non-White (Colby & Ortman, 2015). From 2000 to 2010, the White population increased a modest 5.7%, while the Hispanic population grew by 43% (Humes, Jones & Ramirez, 2011) (see Figure 1). Frey (2014) asserts that this “sweeping diversity explosion” (p. 213) will transform the social fabric of the United States impacting structures such as education in ways unforeseen just
decades ago. These future population projections certainly paint a more inequitable landscape for URM women.

![Figure 1](image.png)

*Figure 1. Percent growth in U.S. population from 2000-2010.
Source: US Census Bureau 2010*

Considering the gender composition amongst STEM graduates apart from racial or ethnic categorisation, women accounted for 38.5% of all STEM bachelor’s degrees awarded in 2010 (NSF, 2013). Across all academic disciplines (STEM and non-STEM), women earned 58% of all bachelor’s degrees conferred in that year. While women and students of colour are both underrepresented in STEM fields, of even greater concern is the dearth of STEM degrees (9%) earned by underrepresented minority women. Yet, what is disheartening is that women of colour possess STEM aspirations at least equal to their White peers (Huang, Taddese, & Walter, 2000; HERI, 2010) but up to this point have been unable to realise those career ambitions.
Significance of Study

Simply stated, science and engineering professions are dominated by White, male workers (Landivar, 2013). As the American population grows increasingly diverse, the scale of this underrepresentation poses major equity issues (Ong, Wright, Espinosa & Orfield, 2011, p.175) as well as highlights the structured inequalities of social class (Seymour & Hewitt, 1997, p. 386). Not only are the potential benefits of diversity in the workplace compromised, but STEM fields provide significantly higher salaries than non-STEM careers, offering the possibilities of greater socioeconomic mobility to an often marginalized segment of the U.S. population (US Dept. Commerce, Economics & Statistics, 2011).

In order to meet the mounting needs of a future STEM workforce, the President’s Council of Advisors on Science and Technology (2012) projects that the number of those majoring in STEM fields of study will need to increase by 33% in order to meet America’s growing and future technological needs. Underrepresented minority women offer the potential to expand the current STEM talent pool and potentially fill a portion of this burgeoning gap (Ong et al., 2011). The diversity explosion that is now underway in the United States will continue to change the social and demographic personalities of all parts of the country in ways that have been unanticipated (Frey, 2014). “The benefits of equity and justice, in conjunction with our country’s shifting demographics and national imperative to further scientific innovation and competitiveness, point to the growing importance of understanding, recruiting, and supporting women of colour in STEM education” (Ong et al., 2011, p.176).

However, since URM women lack significant representation in STEM, their focus as participants in research studies is often not fully examined. Tate and Linn (2005) point out that “this under representation leads to the invisibility of women of
Racial and gender intersections are often neglected in research agendas. In a recent synthesis of the literature on women of colour and STEM, Ong et al. (2011) identified that over the last 40 years, there have been less than 120 published empirical studies that focused on the intersection of race and gender (female) in STEM. While scholarly research in this field is “surprisingly slim in both quantity and quality” (Espinosa, 2011, p. 210), researchers consistently point to the social and structural environments of the university setting as key contributors to the attrition of minority women from STEM disciplines (Ong et al., 2011). Within the context of the college setting, much work needs to be done in order to more fully comprehend the impact of the backgrounds and experiences that actually support underrepresented racial minority women in STEM trajectories.

In crafting studies that consider minority populations who pursue STEM pathways, Harper (2010) asserts that research focus should be aimed towards those who “excel instead of adding to the already well-understood reason why they fail” (p.66). As most prior studies on minorities in STEM amplify deficits, student failure and attrition, Harper challenges researchers to adopt an anti-deficit approach when designing studies that centre upon students of colour in STEM. Employing this approach allows researchers to shift focus away from issues of attrition and failure, and instead, to place emphasis upon how students of colour in STEM actually persist and “manage to successfully navigate their way to college and through the STEM postsecondary pipeline” (p.64). Much can be learned through studying exemplars of persistence, which, despite overcoming significant disadvantage, become models of success.

**Purpose**

The purpose of this study is to gain a better understanding of how the organisational environment and social practices experienced at different types of liberal
arts colleges affect the persistence of URM women in STEM fields of study. Generally speaking, liberal arts colleges, with their concerted focus on undergraduate education, demonstrate more success in retaining STEM undergraduates than do larger research universities (Griffith, 2010; Espinosa, 2011). Additionally, since graduates from liberal arts colleges are twice as likely to earn a PhD in science when compared to graduates from other baccalaureate granting institutions (Cech, 1999), a research study carried out within the context of liberal arts colleges may provide increased access to studying models of success. Aligning with Harper’s (2010) anti-deficit approach, this study aims to offer a comparative analysis of the contributions made by different types of liberal arts colleges (women’s colleges, historically Black colleges and universities (HBCUs), and coeducational) towards promoting persistence for underrepresented racial minority women in STEM with the hope of providing deeper insight into the potential contributions that these unique institutions may offer in empowering women of colour towards success, and in diversifying the STEM workforce.

In essence, this study directs its focus towards URM women who continue to persist in STEM, and not on those who have chosen to leave. Situated as a mixed-methods study within the landscape of liberal arts colleges that have demonstrated an outstanding track record of graduating women in STEM, this study seeks to learn if these “best-case” phenomena of graduating high numbers of women in STEM extends as well to women of colour on these liberal arts campuses, and if so, how (Museus & Liverman, 2010). Since this study focuses specifically on those URM women who have persisted in their STEM studies, college administrators may be able to better understand those positive factors, unique to their campuses, which lead to successful outcomes for minority women in STEM. The outcomes of this study may illuminate how future policies and practices can be shaped to further promote successful gains for women of
colour in STEM within the context of these particular types of liberal arts campuses. At this present time, there appears to be no other study in the literature that offers a comparative analysis of the experiences of successful URM female STEM students at different types of liberal arts colleges. While the results of this study may not be generalised to all liberal arts colleges, or to other types of universities in the United States, new areas of future study may be generated from these results. Therefore, this study may also potentially minimise the gap within this body of academic literature, which is surprisingly limited.

Research Questions

The overarching research question for this study emerges as: What factors promote persistence in STEM for underrepresented racial minority women who attend different types of liberal arts colleges (women’s, coeducational, HBCU) in the United States? A careful synthesis of the literature specific to the success of URM female students in STEM is undertaken in the next chapter, along with a discussion on the relevant theoretical frameworks selected and applied to this study - identity theory, a college socialisation impact model, and theories of cultural and social capital. Based upon the literature and selected frameworks, a conceptual model (see Figure 4) was created that steered the development of guiding research questions further explored in this study. With a focus squarely placed on URM female STEM students who continue to persist towards graduation, the following research questions form the basis of this study:

1. What aspects of pre-college background and inherited cultural and social capital provide the competencies necessary for persistence for women in STEM?

2. In what ways do college experiences, college support structures, perceptions of campus environments and resourceful campus relationships differ for URM and non-URM women who persist in STEM and how do these measures differ for URM women at different types of colleges?
3. How do campus environments and ethnic identity affect the acquisition of cultural capital for URM women who persist in STEM and do prior levels of “inherited” cultural capital affect measures of “learned” capital acquired during the college years?

4. Do campus environments and measures of acquired cultural and social capital affect the formation of science identity for URM women who persist in STEM at a liberal arts college?

5. In what ways do parents, external mentors and other resourceful relationships influence URM women’s continued persistence in STEM?

**Organisation of the Study**

This thesis is organised into seven chapters. Following this introductory chapter, the second chapter of this thesis offers a discussion on the literature relevant to the success of URM women in STEM. The topics covered within this literature review are: Racial and Gender Inequality in Educational Environments, Pre-College Preparation, Spheres of Influence (parents, peers, faculty), The College Environment (institutional support, campus climate and sense of belonging), Student Self-Perceptions and Academic Achievement, STEM Recruitment and Retention Programs, Attrition and Retention Rates, Institutional Types and Persistence (coeducational liberal arts colleges, women’s colleges, historically Black colleges and universities (HBCUs)) and the Impact of Financial Aid. Following the literature review, the second section of the chapter explores the theoretical frameworks considered applicable to the study of URM female STEM students within a university setting. In particular, identity theory, college socialisation models, and theories of cultural and social capital are discussed. The second chapter concludes with a discussion on the formulation of a conceptual model devised for this study, as well as the research questions that guide the direction of this study.

The third chapter explores the methodology of this study and discusses the mixed-methods research design, the positionality of the researcher, a description of the
setting and participants, as well as a detailed explanation of how the institutions and participants were recruited to the study. The chapter then describes both the quantitative and qualitative instruments used in the study, and the validity and reliability of those instruments. The chapter closes with a discussion on the ethical considerations and the perceived limitations of this study.

Expanding on the specific institutional settings of the participating institutions, the fourth chapter explores the educational contexts and specific campus programs at each of the five participating institutions. Descriptions are offered on the various programs and campus sub-environments that may influence persistence decisions for URM female STEM students.

The fifth chapter highlights the results of this mixed-methods study and contains five sections, each section corresponding to one of the five guiding research questions. Both quantitative and qualitative analyses are presented in tandem within each section with the aim of illuminating complementary facets of the research results. Referring back to Chapter Two, the first section investigates the pre-college background and inherited cultural capital of both URM and non-URM female STEM students. The second section explores the college environment, college experiences and resourceful relationships as experienced by both URM and non-URM female STEM students across college types, and by URM female STEM students between college types. The third section highlights the impact of campus environments and ethnic identity, as well as aspects of inherited cultural capital on the acquisition of specific attributes of cultural capital attained during college. The fourth section explores how science identity for URM female STEM students may be shaped by the campus environment and experiences that occur during the college years. The fifth section explores the effects of
relationships with influential others, most notably family and mentoring relationships. The chapter concludes with a summary of findings.

The sixth chapter of this thesis offers a discussion on the background, resources, relationships and experiences that empowered URM female students towards persistence in STEM within the context of a liberal arts college environment. This chapter offers a contextualised discussion of the research results set within the unique landscapes of women’s liberal arts colleges, coeducational liberal arts colleges and an HBCU. Each section of this chapter is organized around a specific aspect of the proposed conceptual model derived for this study (see Figure 4).

The seventh and final chapter of this thesis concludes with a summary of key findings and recommendations for future study or policy considerations for liberal arts college administrators placed within the context of those colleges researched in this study.
Chapter 2: Literature Review and Theoretical Frameworks

This chapter is divided into two distinct sections – a review of the literature and a discussion on theoretical frameworks. The following literature review focuses upon issues relevant to the success of undergraduate women of colour in STEM. Since the literature specifically emphasising minority women in STEM is notably slim, this review at times addresses gender and race as separate constructs and at other times, as the literature allows, as a unified construct. While the terms “women of colour” and “minority women” may be used interchangeably within this review, underrepresented racial minority (URM) women will exclusively refer to those women who are underrepresented in STEM – African American or women of African descent, Latina, Hispanic, and Native American. The topics covered within this literature review are: Racial and Gender Inequality in Educational Environments, Pre-College Preparation, Spheres of Influence (parents, peers, faculty), the College Environment (institutional support, campus climate and sense of belonging), Student Self-Perceptions and Academic Achievement, STEM Recruitment and Retention Programs, Attrition and Retention Rates, Institutional Types and Persistence (private liberal arts colleges, women’s colleges, historically Black colleges and universities (HBCUs)) and the Impact of Financial Aid. The first section of this chapter concludes with a summary and recommendations for future study found in the literature.

The second section of this chapter explores the theoretical frameworks considered applicable to the study of URM female STEM students within a college setting. In particular, identity theory, college socialisation models, and theories of cultural and social capital are discussed. Although a large body of research exists on the retention and persistence of students in a college setting, less is known about the specific influences that affect retention for students from culturally diverse backgrounds.
Based upon a synthesis of the literature and an analysis of relevant theoretical frameworks, a conceptual model for this study was devised and research questions were generated that relate specifically to the persistence of URM female students in STEM fields of study.

**Racial and Gender Inequality in Educational Environments**

In the United States, race has functioned as an obstacle to increased educational opportunities and socioeconomic change. Yet, issues surrounding race must be confronted for educational transformation to occur (Banks, 1988; Yosso, 2005; Harper & Hurtado, 2007). From the very beginning of their schooling, girls of colour face multiple kinds of discrimination. Feminist theorists such as Beverly Skeggs and Diane Reay suggest that the types of social forces that exist in contexts such as education are influential in furthering inequities within race and gender (Dillabough, 2011). For underrepresented minority women, gender-based socialization contributes to the notion that women are not compatible within the competitive domain of science (Seymour & Hewitt, 1997). “Gender and racial bias within institutions places women of color at a double disadvantage as the combination of being female and a person of color hinders their access to science” (Ceglie, 2011, p. 272). STEM students from underrepresented minority groups often find themselves having to navigate the rifts that exist between their ethnic cultures and the culture of science which is perceived as both highly rational and impersonal (Chavez & Guido-DiBrito, 1999).

Women of colour in STEM are continually challenged with conflicting value systems and instances of racism, and as a result often have to deal with lowered academic expectations (Chinn, 1999). In navigating life on the college campus, and more specifically at principally White institutions (PWIs), students of colour often experience feelings of ethnic isolation and the internalization of stereotypes (Loo &
Rolison, 1986; Seymour & Hewitt, 1997; Steele, 1997). While many minority students face continual pressure to adapt to the predominant culture that is encountered within their higher education context, many White students on campus lack a “recognition that interracial tensions and conflict exist for a significant portion of the student body” (Ancis, Sedlacek, & Mohr, 2000, p. 183) who are racially diverse. Within a higher education context, perceptions of racial climate powerfully impact student attitudes and behaviours, and as such become an important area for examination (Milem, Chang, & Antonio, 2005; Pascarella & Terenzini, 2005; Harper & Hurtado, 2007).

On college campuses, minority students often face “microaggressions”, subtle yet continual “racial assaults” that are often riddled with hidden messages of rejection (Yosso, Smith, Ceja & Solorzano, 2009, p. 660). While these ongoing, and sometimes unconscious racial attacks may at face value appear harmless, over time these messages may erode a minority student’s confidence and self-esteem, qualities that are necessary for persistence. Some students may “depersonalize” this type of negative commentary as a way to develop the agency to press on (Hendricks, Smith, Caplow & Donaldson, 1996, p. 121). Yosso et al. (2009) note that in order to persist, minority students also create culturally supportive “academic and social counterspaces” (p. 660) which facilitate not only safe havens but spaces where minority students communally learn the navigational skills required to direct the course of their education. In some ways, the students who gather collectively within these counterspaces create a fictive kin group for the purpose of aiding and empowering one another with the specific goal of completing their tertiary degree (Tierney & Venegas, 2006). The path is neither a smooth nor easy one for many URM women in STEM. For many women of colour who persist in STEM, their journeys often reveal stories of resiliency and empowerment in spite of enduring opposition and oppression (Chinn, 1999).
STEM students who are both female and from an underrepresented minority group often face unique concerns and barriers; studying the intersection of race and gender may reveal nuances less understood than if women of colour are simply categorized into specific separate homogeneous groups (Tate & Linn, 2005; Lord et al., 2009; D. Johnson, 2011, Malcom & Malcom, 2011). The underrepresentation of minority women in STEM highlights the racial and gender inequalities that exist within America’s higher education system, and is also reflective of the apparent disparities within social class (Seymour & Hewitt, 1997). Aside from the hurdles aspiring women in STEM face because of their minority and gender status, the additional “oppressive effects of low socioeconomic status” (Vasquez, 1982, p. 147) may even further deter minority women from participation in higher education.

**Pre-College Academic Preparation**

The fact that relatively few African American, Hispanic and Native American students actually complete high school with the mathematics and science background needed for success in STEM has been a concern, and in turn undermines STEM participation at the university level (Clewell & Campbell, 2002; Seymour & Hewitt, 1997). In their landmark study on university and college students who leave the sciences, Seymour and Hewitt (1997) found that minority students who did not persist in STEM often noted that inadequate high school preparation led to barriers in conceptual understanding with college coursework. For minorities and students from low socioeconomic backgrounds, appropriate STEM course taking at the high school level has often been plagued by a lack of academically challenging mathematics and science classes as well as a scarcity of skilled high school mathematics and science teachers (S. Johnson et al., 2001; Ndura, Robinson & Ochs, 2003).
However over the last decade, all women, including women of colour, have made noteworthy gains in completing high school courses that contribute to a firm foundation of knowledge essential for future STEM study (Foltz, Gannon & Kirschmann, 2014; NCES, 2000, 2009). Of particular note is the increase by Black and Hispanic high school women in precalculus and calculus course taking. Between 2000 and 2009, Black women increased their rate of precalculus course taking by 43%, and in that same time period, Hispanic women increased their rate of calculus course taking by 44%. While the rate of participation in challenging secondary school mathematics courses is increasing for minority and non-minority women alike, less than 10% of all females who graduated from high school in 2010 completed either the AP CalculusAB or the AP CalculusBC course (Mattern, Shaw & Ewing, 2011). Mathematics is often perceived as a “critical filter” providing access for minority women into career pathways such as STEM (Sells, 1973). Additionally, between 2000 and 2009, the number of Hispanic women who completed all three high school science courses in biology, chemistry and physics increased by 23% (NCES, 2000, 2009). While these figures are encouraging, there is still a long way to go for women of colour to achieve parity with White and/or Asian women’s participation in relevant STEM high school courses.

Pre-college academic preparation for minority students is highly correlated not only to STEM persistence, but also to the selection of a STEM major (Cole & Espinosa, 2008; Huang et al., 2000). Several researchers have found a direct positive correlation of Advanced Placement mathematics and science course taking in high school with the selection of a mathematics/science related major at college (Morgan & Klaric, 2007; Robinson, 2003; Correll, 2001). In Morgan and Klaric’s (2007) study, minority and female students who had completed either Advanced Placement Biology or Advanced
Placement Chemistry were at least three times more likely to major in a mathematics or science related area than students who had not taken those STEM specific Advanced Placement courses. After controlling for background variables, including prior levels of student achievement, Tai, Liu, Almarode and Fan (2010) discovered that students who had enrolled in Advanced Placement Calculus were at least four times more likely to select engineering, chemistry, physics or astronomy as a course of study in college. Even taking just one AP STEM related course in high school may impact persistence in a STEM major at college (Shaw & Barbuti, 2010).

In the United States, Advanced Placement classes are often considered the most rigorous curriculum offered at the high school level, as students can potentially earn university level credit. However, “underserved minority and low-income students remain underrepresented in AP classrooms, and we continue to face challenges in transforming the educational experiences of underserved students in this country” (College Board, 2012, p.16). Of high school students who graduated in 2011, African American students were the least represented racial group in AP course participation; while they comprised fifteen percent (15%) of the student population, only nine percent (9%) participated in the AP student program (College Board, 2012).

Not all students though have access to rigorous high school curriculum which includes opportunities to enrol in AP courses. Students from under-resourced high schools can often benefit from participation in a college preparation program which Tierney and Jun (2001) define as “enhancement programs aimed at increasing access to college for low-income youth” (p. 206). Many of these programs work towards filling knowledge gaps in the college-going process by assisting students with preparation for university entrance exams (SAT/ACT), assistance in mathematics and science course work, college counselling, general academic enrichment, mentoring and access to

Relative to academic achievement, there appears to be conflicting evidence on the relationship between high school grade point average (GPA) and STEM persistence at the university or college level. While Espinosa (2011) found that pre-college GPA affected STEM persistence for women of colour, Grandy’s study (1998) determined that high school mathematics/science achievement was not directly related to persistence for a large sample of minority students. However, this may be due to the selected sample in Grandy’s study which only included high-ability minority students, both male and female. In the high school classroom, female students consistently outperform males. In 2005, overall GPA for females and males was 3.09 and 2.86 respectively, and mathematics/science combined GPA was 2.76 and 2.56 respectively (NCES, 2005). Across all ethnicities women earn higher GPAs than men (Lord et al., 2009).

Considering the school environment in which academic achievement occurs, little is known about the type of high school URM women attend and the effect this environment may have on subsequent persistence in a STEM field. In the United States, students who attend a private high school graduate from university at near double the rate of those who attend public schools (Lauff & Ingels, 2013), as the resources available in private institutions often exceed those available in many urban public schools (Neal, 1998). Although there is some evidence that young women who have attended single-gender high schools may be more likely to major in STEM fields such as engineering when compared to young women who attended coeducational high schools (Goodman, 2002; Tully & Jacobs, 2010), there is a wide gap in the literature on the types of high schools attended by women of colour who eventually choose a higher education STEM pathway (Espinosa, 2009).
Pre-College STEM Aspirations

Many studies on gender and the selection of a college major often neglect to consider how the dynamics of social class or ethnicity may affect this choice (Mullen, 2010). While there appears to be significant gender differences in pre-college aspirations towards a future STEM post-secondary academic path (Xie & Schauman, 2003), when comparison is made within the parameters of gender, minority women express a strong interest in science and engineering and at times demonstrate a greater inclination than White or Asian women to pursue a course of study in a STEM field (Huang et al., 2000; Malcom & Malcom, 2011; HERI, 2010).

Women and men display differences in their reasons for initially pursuing science or engineering at college. For some young women, an affirming relationship with a science or mathematics teacher influences their decision to pursue a STEM field of study after high school (Fries-Britt, Younger & Hall, 2010). Seymour and Hewitt (1997) found that women were twice as likely as men to enter STEM because of the encouragement of a parent, high school teacher or other influential adult. Yet, through following the advice of others, some women had less personally defined views of what they expected from their college experience, which in some cases led to abandoning the STEM path at college. While the motives for women of colour choosing the STEM pathway are complex, very few students who first choose a non-STEM field of study in college will actually reorient towards a future STEM trajectory (Syed, 2010).

Minority women often cite altruistic reasons for pursuing a science or engineering degree (Carlone & Johnson, 2007). The National Academy of Engineering (2008) conducted a study that tested slogans which focused on raising the appeal of engineering for a future generation. Interestingly, White young women most selected the phrase “engineers make a world of difference”, whereas African American and
Hispanic young women cited “engineering is essential to our health, happiness and safety” as the most persuasive message. For these young URM women, there was a natural linkage between the field of engineering and how engineering may open the door for improving the lives of others. Exploring the reasons why students at an ethnically diverse college chose to embark upon an engineering degree program, Martin-Trenor, Yu, Waight, Zerda and Sha (2008) discovered that Hispanic students were most often motivated by the desire to support family, African American students desired to use their skills to reinvest into their communities, and Asian American and White students were both inspired by a sense of personal accomplishment. Phinney, Dennis and Osorio (2006) also suggest that in addition to providing assistance to their families, students of colour pursue STEM because of a deeply embedded desire to confirm their own self-worth. Moreover, Huang et al. (2000) posit that there also appears to be a self-selection mechanism at work that “filters out a small group of highly resilient women for science and engineering programs. These women are likely to have strong family support, high expectation, healthy self-confidence and solid academic preparation” (p. 88) – necessary factors not always present amongst young women of colour.

Spheres of Influence

Parental Influence. In surveying over 20,000 undergraduate engineering women from across 50 institutions, the Women Experiences in College Engineering project (Goodman, 2002) determined that a majority of women have long-held beliefs about pursuing engineering, and that these beliefs are primarily attributable to parental encouragement. Minority women in STEM often identify the support that comes from their homes and communities as an essential foundation from which they draw the necessary encouragement for persistence (Grandy, 1998; Russell & Atwater, 2005;
Ellington, 2006). However, as Ong et al. (2011) note, families may exert influence on their daughters to choose a more traditional path that includes marrying and raising a family, thus discouraging some young women of colour away from a higher education path in STEM.

Parental educational expectations play a vital role in the future success of URM young women in their STEM related studies in college. Huang et al. (2000) found that parents of young minority women (12th grade) held much higher levels of educational aspiration for their daughters than did parents of White or Asian young women. In their study that explored the experiences of successful URM STEM graduates, Foltz et al. (2014) found that parents of minority STEM graduates placed a high value on their children not only attending college but also in pursuing a STEM degree. Yet, while minority parents may encourage their daughters to aspire to higher levels of education, the family resources needed to attain those educational goals may not be clearly understood, and with a lack of supportive resources, the college going habitus displayed by parents may not directly translate to academic advantage for their daughters (Chavira & Mena, 2011).

The effects of parental influence are well documented across a vast spectrum of educational literature. While parental encouragement plays a substantial role in the educational outcomes of children, parents’ educational levels seem to be less influential in regards to degree attainment for women of colour in STEM. Examining the experiences of 1250 women of colour through the Cooperative Institutional Research Program (CIRP) at UCLA, Espinosa (2011) found that parental socialization (parents’ educational level, parents’ STEM occupation) was not significantly aligned with persistence in STEM, although it was significantly correlated for White women (father in a STEM occupation). Additionally, Cole & Espinosa (2008) found that parents’ level
of education had little bearing on student academic success in STEM for Hispanic students who were the first in their families to attend college. They posit that first-generation college students who persist may appropriate new sources of cultural capital through resource rich relationships with faculty and peers that in turn positively affects academic outcomes. However, when considering issues related to attrition, Engle and Tinto (2008) determined that first-generation college students are almost twice as likely to exit STEM and leave college altogether than their peers whose parents completed a university degree, highlighting the increased obstacles that many first-generation students face.

**Peer Influence and Peer Networks.** Interaction amongst peers and peer group affiliation in the college environment can greatly influence the social and cognitive development of students. In his landmark study, *What Matters in College*, Astin (1993) found that student learning and aspects of personal development were significantly affected by the quality and type of peer interactions that students encountered while on campus. For women of colour in STEM, peer support is associated with persistence (Wao, Lee & Borman, 2010; Espinosa, 2011) and in particular, women who participate in STEM specific academic programs, such as the Society of Women Engineers find a supportive network which is often associated with retention (Brainard & Carlin, 1998, Espinosa, 2011). Additionally, campus diversity organisations may offer URM female STEM students the space in which to form affirming relationships with other URM students in STEM (Museus & Quay, 2009). On some campuses, minority women have formed *sister circle* groups that facilitate specific forms of friendship focused on encouragement towards achieving educational goals (Niskode-Dossett, Boney, Bullock, Cochran & Kao, 2012). While these cultural enclaves or fictive kin groups may offer a place of support and empowerment for URM
female STEM students (Kuh & Love, 2000; Tierney & Venegas, 2006), the low enrolment of minority students in STEM at PWIs may limit the opportunities for groups such as these to form (Museus, 2008).

URM women often experience feelings of alienation and can find it difficult to mediate the social distance in a group whose membership lacks students from similar backgrounds for mutual support (Tate & Linn, 2005). When students of colour experience a divide between the values displayed in their STEM departments and those held by their peers outside of STEM, they are more prone to exit the STEM pipeline (Bonoous-Hammarrth, 2000). In order to gain effective peer support and find communities of students with whom to identify, women of colour in STEM often have to look outside these type of academic networks and look towards their ethnic/racial groups to find the affirmation and encouragement they need to sustain persistence (Ong et al., 2011).

Most studies that explore the academic and social gains of students who participate in and affiliate with campus student groups are drawn from samples of predominantly White students (Montelongo, 2002), and less is known about the effect on positive academic gains for students of colour in STEM who participate in activities with ethnically-based campus groups. More recent studies have pointed towards the negative effect on GPA of attending university sponsored diversity events. Cole and Espinosa (2008) found that Hispanic students who attended diversity related functions actually experienced lower grades. They postulate that Hispanic students may participate in these social gatherings in order to find the interpersonal dialogue, support and acceptance that is lacking in their relationships within their academic departments. In a study of high-ability minority students, Grandy (1998) found that females who were socially active with leadership responsibilities were marginally less inclined towards
STEM degree attainment. She suggests that women who place a high value on social relationships may be eventually drawn towards what may be perceived as more altruistic career paths. In negotiating the various responsibilities in the multiple contexts of campus life, time spent on social events and away from studying may ultimately have a negative effect on academic achievement (Pascarella & Terenzini, 2005).

In their case study that explored the factors that promoted persistence for African American women in STEM at a women’s HBCU (Spelman College), Perna et al. (2009) attributed a supportive academic peer culture to faculty who encouraged and facilitated student participation in study groups and in peer tutoring. Peer support networks are critical to the achievement of women of colour in STEM. Yet looking beyond peers, social networks which include faculty and other college personnel are essential in sustaining and enabling women to experience the types of personal and academic successes that will ultimately lead to persistence (Ong et al., 2011; Nguyen, 2015).

**Faculty Influence.** In conjunction with the influence of peers, student-faculty relationships are positively correlated to every self-reported aspect of students’ academic and individual development (Astin, 1993). For women in STEM, the encouraging tenor of faculty-student conversations facilitates the process of learning, increases student confidence and promotes student retention (Seymour & Hewitt, 1997; Cokely, 2000; Hurtado et al., 2011). Faculty also play a key role in assisting minority students in envisioning themselves as STEM professionals (Foltz et al., 2014) and effective pedagogical practices not only influence women’s participation and confidence in the STEM classroom, but are also critical in women of colour persisting to graduation (Seymour & Hewitt, 1997). “Students’ gains in confidence, motivation, responsibility and intent to persist were influenced more by teaching practices than by
student background characteristics” (Colbeck, Cabrera, & Terenzini 2001, p. 185). Within the STEM classroom context, collaborative learning opportunities, coursework-based peer conversations both in and out of the classroom, as well as faculty-student interactions, guided students towards increased academic and career perceptions. Colbeck and colleagues (2001) noted that within the STEM classroom, preferred instructional practices differed by gender. Women students highly valued teaching that was organized and clear, while male students related gains in confidence to teacher dialogue and feedback.

In the STEM classroom, men often get more of the instructor’s attention (Seymour & Hewitt, 1997). While women may ask more questions in class, seek out an instructor’s guidance outside of class more often, and spend equal time using scientific equipment, men still receive a larger share of the instructor’s attention (Greenfield, 1997). “For women, this failure to encourage is taken as discouragement” (Seymour & Hewitt, 1997, p. 270). Due to their gender and ethnicity, some women of colour perceive a lack of respect by faculty in recognizing them as serious science students (Carlone & Johnson, 2007) and some students perceive the classroom environment as too competitive (Ceglie, 2011). However, the minority women in Seymour and Hewitt’s study (1997) stressed that some of these negative experiences actually made them more determined to succeed. While the reasons URM female STEM students leave STEM are multi-faceted, poor teaching (Seymour, 2002) and the inaccessibility of science curriculum through ineffectual pedagogical practices (Espinosa, 2011) are directly related to student departure.

Perna and her team (2009) discovered that small class sizes at the all-female Spelman College (HBCU) were helpful in promoting student faculty interactions which led to women’s gains in STEM classroom achievement. Similarly, A. Johnson (2007)
found that large lecture classes in many STEM subjects actually posed an internal conflict for women as they had to endure the impersonal mass learning environment where race and gender did not seem to matter.

The relationship between the ethnic origin of STEM faculty and student persistence is not clearly understood (Espinosa, 2009). However, there does appear to be some strong linkages between female persistence in STEM and the increased percentage of female faculty in STEM (Sonnert, Fox & Adkins, 2007). In a recent study conducted by Griffith (2010), the increased rate of female STEM faculty was related to increasing rates of persistence for minority students, a trend not displayed with non-minority students. Female faculty may offer URM female STEM students increased role model relationships which are so often lacking in the college and university STEM environment. In general, women in STEM who form bonds with other female role models in STEM are more likely to persist (Goodman, 2002).

The College Environment

As organisational structures, colleges can be seen as “gatekeepers” that not only control who is qualified for access, but also act as socialising agents offering their students certain benefits of socioeconomic status through future career trajectories (Pascerella & Terenzini, 2005, p. 51). College environments and the factors that enhance the success of students in STEM may differ by gender, race and ethnicity (Huang et al., 2000; Wolf, 2000). Since the outcomes of undergraduate education directly shape the alignment of a future STEM workforce, it is critical to gain a deeper understanding of how the forces at play in the educational context actually influence the racial and gender composition within it (Sonnert et al., 2007). For URM female students, the major factors that contribute to their persistence in STEM fields may be better understood through gaining a greater recognition of the interplay between the
college environment and the college experience in the lives of students (Espinosa, 2011). There is certainly much to learn about the college experiences of undergraduate women in science, especially those experiences of women of colour in STEM (Seymour & Hewitt, 1997).

For many minority students, difficulties arise when the socially constructed nature of educational institutions comes in direct conflict with students’ own cultural values, behaviours and modes of learning (Chavez & Guido-DiBrito, 1999). Sonnert (1999) suggests that perhaps when studying college contexts for women in science, more focus needs to be applied to individual departments in order to examine not only the calibre of teaching but the practices that are in place which reflect a positive track record on female retention. Rayman and Brett (1995) found that persistence for women in their career paths was not consistent among the different STEM academic disciplines. Cross-institutional research could shed light on the effects of departmental practices as well as potential differences in the types of learners who choose to study within the different STEM disciplines.

**Institutional Support.** Female students who perceive their institution as student-centred enjoy a more satisfying college experience and aspire to higher levels of academic achievement and degree completion (Smith, Wolf & Morrison, 1995). In Martin-Trenor and colleague’s study (2008), female engineering students experienced positive institutional support when situated within an ethnically diverse learning environment. However, first-generation engineering students in that same environment perceived less support than engineering students whose parent(s) had graduated from college. Seymour and Hewitt (1997) found that persistence in science increased for Hispanic and Native American students when institutions made an effort to duplicate
within campus life the supportive extended-family networks present within these students’ ethnic cultures.

Awareness of the quality of support structures offered by a university or college may influence a student’s choice to major in a STEM field. Tang (as cited in Good, Halpin & Halpin, 2002) suggests that Black students who perceive inadequate institutional support are less apt to major in engineering. Seymour and Hewitt (1997) also note that more than three quarters of minority students who switch out of science cite the lack of institutional resources as influential in their decision to exit STEM. Yet not all students respond favorably to support systems or institutional programs specifically designed for underrepresented minorities. In a study conducted on a campus with a predominantly multi-ethnic student population, “the presence of ample support systems for all students, not based on ethnicity, contributed to students’ sense of belonging and positive educational experiences” (Martin-Trenor et al., 2008, p.461).

**Campus Climate and Sense of Belonging.** The STEM classroom and laboratory environment have often been described as unwelcoming and *chilly* towards women and minorities (Hall & Sadler, 1984; Brush, 1991). A science culture built on traditional White male values can often permeate the classroom environment resulting in a loss of self-confidence and STEM career ambition for women and minorities (Hall & Sadler, 1984). A chilly climate contributes to feelings of isolation and of emotional detachment from academic departments, and is often cited as contributing to the departure of women who choose to leave the STEM pathway during their undergraduate years (Goodman, 2002). Female students of colour describe the competitive climate of many STEM classrooms and an exceedingly competitive and overtly male culture contributes to the attrition of women, and more specifically for women of colour in STEM (Ceglie, 2011). However, when only looking at gender, and not gender and race,
Seymour and Hewitt’s (1997, p. 232-233) study suggests that the competitive atmosphere in science affects fewer women in their decision to switch out of STEM as compared to men.

The climate within a STEM classroom may also display differing shades of discrimination. Colbeck et al. (2001) determined that female engineering students perceive greater levels of gender discrimination from their male classmates than they do from their interactions with faculty. Additionally, as science classrooms provide regular opportunities for hands-on group learning activities, women observe that male students treat them differently when working in small groups. Within the STEM classroom, Seymour (1999) describes the exasperation women experience because of the incessant bad-mannered behaviour of male classmates. However, women may need to reach a critical mass within STEM classroom cultures before negative effects, such as undesirable male behaviour, may noticeably be reduced (Clark Blickenstaff, 2005). Etzkowitz, Kemelgor, Neuschatz, Uzzi, & Alonzo (1994) suggest that minority students in science may need to reach a critical mass of approximately 15% representation in a classroom setting before change may be influenced. Classroom climates that display equity and are hospitable to women actually benefit all students, not just those in the minority (Colbeck et al., 2001). Although women and men sit side by side in the classroom, the way each gender experiences the classroom environment may also be perceived differently (Crawford & MacLeod, 1990).

Wao, Lee and Borman (2010) recently conducted a study which assessed aspects of classroom climate that promoted completion of engineering degrees for women and minorities. Their research found that women and minority students experienced very subtle forms of sexism and racism within STEM departmental cultures. Focus groups and interviews revealed that women and minorities were not treated differently per se;
the experienced feelings of oppression were more shaped by the different ways in which climate was perceived by students in the minority. Discrimination hinders the intellectual growth and social development of minority students and results in isolation from peers and faculty (Smedley, Myers & Harrell, 1993). Yet, institutional environments that exhibit a campus-wide equitable and positive racial atmosphere may actually contest the negative aspects of racism experienced within STEM departments (D. Johnson, 2011).

Regardless of race, “how well a student adjusts to the academic environment of college is thus closely tied to their developing sense of belonging” (Hausmann, Scholfield & Woods, 2007, p. 829); in turn, a positive sense of belonging increases a student’s intention to persist. While African American engineering students who experience a sense of belonging within their academic community are more likely to persist, Black students who attend principally White institutions (PWIs) may find it more difficult to experience a sense of belonging within campus communities (Lett & Wright, 2003).

D. Johnson’s research (2011) highlights the complexities when considering the intersections and linkages between racial climate, institutional racial composition and sense of belonging for URM female students in STEM. “Being a woman of colour has a negative relationship to overall sense of belonging…race/ethnicity plays a powerful role in the extent to which women in STEM experience overall sense of belonging to their campus” (p. 343). Campus environments, particularly negative racial climates, are known to impact student grade performance as well as student satisfaction, factors that are inextricably linked to retention (Charles, Fischer, Mooney & Massey, 2009). For women of colour, the lack of peers within STEM departments can lead to a sense of isolation and psychological alienation, not only impacting students’ sense of belonging,
but also affecting their self-esteem, identity and likelihood to persist (Seymour & Hewitt, 1997). However, minority women who participate in undergraduate research experiences confirm their science identities and increase their chances of persisting in STEM (Carlone & Johnson, 2007; Hurtado, Cabrera, Lin, Arellano & Espinosa, 2009; Espinosa, 2009; Chang, Sharkness, Hurtado & Newman, 2014).

**Student Self-Perceptions and Academic Achievement**

While self-perceptions of ability and self-confidence contribute significantly to the persistence of underrepresented minorities in STEM, the sources of undergraduate students’ self-perceptions are often under-researched (Linn and Kessel, 1996; Colbeck et al., 2001; Goodman, 2002). For minority students, the effective use of internal resources to effectively cope with issues of racism, in tandem with certain non-cognitive factors such as self-concept, may in fact be more instrumental in understanding retention than cognitive factors (Sedlacek, 1999). For women, self-perception of quantitative abilities is often shaped through the encouragement and support of family members and teachers, as well as from peers. These positive self-efficacy beliefs provide women with the drive to continue despite academic and financial hurdles, which can be significant for underrepresented women (Zeldin & Pajares, 2000). For some minority students who enter STEM from disadvantaged secondary school programs, their positive self-concept prior to college entry may be derived from high levels of academic achievement relative to their disadvantaged peers. Yet, when entering a STEM tertiary program, they can be poorly prepared for the rigours of college-level academic work in STEM and this clash between inadequate preparation and inflated self-assurance leaves them at high risk for either exiting STEM or leaving college all together (Seymour & Hewitt, 1997). As it affects motivation, perseverance hinges upon positive self-efficacy beliefs (McCombs & Whistler, 1989).
However, self-concept is not considered a fixed entity, but is further formed during the undergraduate years. For women of colour the development of academic self-concept is often linked to working with other students on group projects, strong academic expectations and peer tutoring (Espinosa, 2009). In a comparative study of African American students at PWIs and HBCUs, Cokely (2000) discovered that for students at a PWI, self-concept was most affected by measures of academic achievement whereas for students at an HBCU, self-concept was most influenced through faculty-student connections. His research alludes to how the development of students’ self-concept may be influenced through the ways in which students experience the unique attributes of different types of higher education institutions.

For many women, self-concept is often attached to an extrinsic sense of identity where the approval of others is tied to self-worth. However, as Seymour & Hewitt (1997) note, for Black women in science a different pattern of socialisation emerges. Black women are often inner directed and often exhibit qualities of self-reliance and assertiveness. They are more independent and determined than most other women and Black men. These traits lead to higher levels of self-esteem and higher career expectations for Black women (Pearson & Bieschke, 2001).

Minority women also grow in their personal agency and motivation during college. The source of this ambition may be attributed to the ways these women tap into their ethnic and cultural identities, further empowering themselves towards persistence (Ellington, 2006). However, some women change course due to decreased levels of science ambition, even though they may have higher STEM GPAs than men. For high-ability minority women, academic achievement in STEM subjects does not fully predict STEM persistence (Seymour & Hewitt, 1997; Grandy, 1998; Goodman, 2002). Although women may achieve higher grades than men, they may find the harsh grading
policies in STEM classes discouraging (Rask, 2010) and in turn may redirect themselves towards majors where they find greater affirmation (Goodman, 2002; Ost, 2010). It becomes apparent that other socialisation factors apart from academic achievement are at play that shape and direct URM female STEM students’ academic trajectories.

**STEM Recruitment and Retention Programs**

Peer interactions in STEM minority retention programs are seen as vital in encouraging both cognitive and non-cognitive development for students of colour (Good, Halpin & Halpin, 2002). For women who have limited interactions with those from their peer groups, involvement with women-only STEM programs may promote women’s social connection allowing for deeper peer involvement, while at the same time encouraging academic growth (D. Johnson, 2011). Science and engineering recruitment programs may positively impact STEM enrolment patterns of minority students, but for students to persist they may need to seek additional outside assistance often in the forms of parental encouragement and influential role models (Huang et al., 2000; Martin-Trenor et al., 2008).

Students from lower socioeconomic backgrounds often face additional hurdles to overcome in order to remain enrolled in college. Participation in minority support programs can prove influential in helping students overcome barriers that may hamper their success in STEM through extending students’ social networks (Grandy, 1998; Museus, 2010). Good, Halpin and Halpin (2002) found that African American students enrolled in an engineering support program during the first year of college had higher retention rates than students who did not participate in the program. All but one of the persisting STEM students of colour in Ceglie’s (2011) research study had participated in some type of program intended to support students of color in STEM. While recruitment
and retention programs may initially increase participation of underrepresented minority students in STEM in the early college years, staying and not switching out of STEM may require a different set of interventions.

As minority students begin their college experience, summer Bridge programs prior to matriculation in STEM have been found to be successful in yielding high retention results for students persisting into their second year of study (Pascarella & Terenzini, 2005). These programs aimed at minority and under-resourced students not only offer mathematics instruction and remediation, but also familiarise students with the skills necessary for college success such as how to access campus services, how to approach faculty effectively and how to join study groups. However, retention and recruitment programs which have a remedial focus can also be subject to negative stigmatization. Huang et al. (2000) suggest that enrichment programs offered to all students may work better than remedial programs targeted at specific groups as there is less negative association with inherent issues of underachievement. Though, it cannot be assumed that what may work as an effective program to retain the general student population in STEM within a specific institutional context will also meet the needs and offer the same outcomes more specifically for URM female STEM students in that same educational environment. (Syed, Azmitia & Cooper, 2011).

Some higher education programs aimed at minority retention in STEM retention have found mentoring to be a key intervention strategy within their programs. Solorzano (as cited in Tsui, 2007) determined that for students involved with the Chicano/a Ford Foundation Minority Fellowship, the most prevalent reason cited in promoting persistence for these minority fellows was an affirming mentoring experience. Informal mentoring relationships that emerge more organically from relationships already established within a higher education context may result in more
positive outcomes for students (Davidson & Foster-Johnson, 2001). Yet, URM female STEM students are likely to encounter obstacles in forming more naturally occurring mentoring relationships due the scarcity of minority females within STEM faculties (Jacobi, 1991). Davidson and Foster-Johnson (2001) suggest though, that the qualitative attributes of a mentoring relationship may actually be more important than the one-dimensional structural facets of the racial or gender composition within the mentoring relationship.

**Attrition and Retention Rates**

Perhaps due to their reduced numbers in many STEM disciplines, there is a common perception that females exit the STEM pipeline at greater rates than do males. However, the data to support this assumption is not precisely clear or exact. Two key issues cloud the consistency between research results published in different studies when reporting attrition and retention rates in STEM:

1. The different use of what majors constitute a STEM field of study.

2. The point at which intention to major in a STEM field is determined.

The National Science Foundation (NSF), the U.S. Department of Education/National Center for Education Statistics (NCES), and the National Science Board (NSB) which oversees the NSF, each assign different fields of study when determining STEM fields (Chen, 2009). The NCES traditionally considers natural sciences (biology), health sciences, agricultural sciences, physical sciences, engineering, mathematics, and computer science as STEM fields of study. The additional majors of psychology and social sciences (political science, economics, ethnic studies, anthropology, sociology, etc.) in the NSF’s definition of STEM fields of study skews research results and does not allow for comparison to studies which focus more on the *hard sciences* definition of STEM fields as used by the NCES. The NSB further
extends the STEM majors used by the NSF and more recently added “communications” to its STEM list of majors. Also, the entry point into STEM impacts the determination of attrition rates. Some studies measure intention to major in STEM from pre-college aspirations while others may measure STEM entry from the point when a student “declares” his or her major after college matriculation (Chen, 2009).

Several studies highlight the gender persistence rates in STEM for men versus women, though not disaggregated by gender and race. A NCES study, authored by Huang et al. (2000) determined that women in STEM actually had higher persistence rates than men (49% vs. 40%). Using several large national datasets, including the Baccalaureate and Beyond Longitudinal Study, Xie and Schauman (2003) also concluded that, overall, women did as well as men, if not better, in completing undergraduate STEM degrees. Using a large national dataset (n >79 000), Lord et al. (2009) determined that women who initially identify as a STEM major are more likely than men to change majors to a non-STEM field during their undergraduate years. This trend was equally evident among White and URM women. When considering data from twenty-three highly selective institutions, Smyth and McArdle (2004) found that in science, men had a 66% persistence rate versus a 48% persistence rate for women. Switching out of STEM most occurs in the first or second year of study (Brainard & Carlin, 1998; Gainen, 1995) and, for both genders, completing the second year in a STEM major indicates a high rate of eventual STEM degree completion (Grandy, 1998).

The data paints a more consistent, yet disheartening picture on the persistence rates of students of colour. When considering the attrition rate of minority students in science and mathematics, Culotta (1992) determined that 65% left between the first and third year of university compared with 37% of White students. The Center for Data
Exchange and Analysis (Tan, 2002) determined that in the 1993-1994 academic year, 41% of White and Asian-American students completed their STEM degree within 6 years of enrolment compared to 23% of underrepresented minority students. Huang et al.’s (2000) analysis of the Beginning Postsecondary Study data (n= 859) concluded that within 5 years of enrolment in STEM, 46% of White and Asian-American students completed their STEM program compared to a 27% completion rate for URM students. This study included certificate, associates and bachelor’s degree students. However, the studies thus noted did not offer a comparison of retention rates for students who did not major in a STEM field. Using data from the CIRP Freshman survey, with a sample size of 201,588 students enrolled at 326 four-year non-profit universities, the Higher Education Research Institute’s (HERI, 2010) findings indicate similar disparities, as well as a comparison to non-STEM counterparts. Their analysis, broken down by ethnic/racial groups, measures STEM intention for students who initially planned to major in a STEM field prior to college matriculation; in this analysis, STEM fields of study do not include the majors of psychology, social sciences or communication studies (see Table 1).

**Table 1**

*Five Year Completion Rate of 2004 First-Year College Students, by STEM Aspiration and Race/Ethnicity*

<table>
<thead>
<tr>
<th></th>
<th>5 Year Completion Rate: Started in STEM Field</th>
<th>5 Year Completion Rate: Started in non-STEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>33%</td>
<td>73.5%</td>
</tr>
<tr>
<td>Asian-American</td>
<td>42%</td>
<td>65%</td>
</tr>
<tr>
<td>Black</td>
<td>18.4%</td>
<td>58%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>22.1%</td>
<td>67.6%</td>
</tr>
<tr>
<td>Native-American</td>
<td>18.8%</td>
<td>60.5%</td>
</tr>
</tbody>
</table>

*Source: Higher Education Research Institute at UCLA; Research Brief, January 2010*
While this data highlights the lack of parity across race/ethnicity of completion rates of STEM bachelor’s degrees, it is not additionally disaggregated by gender. The number of minority students who graduate in STEM each year is measured by the National Center of Education Statistics (NCES), yet data on persistence rates by gender and ethnicity/race is less available. The benefit of multiple data sets is that it allows patterns to emerge. Yet, when looking more closely, persistence rates may vary by institution (Lord et al., 2009), suggesting that the type of institutions URM women attend affects the probability of persisting to degree completion in STEM. The following section reviews different types of higher education institutions and the related success of women of color in STEM who attend these institutions.

**Institutional Types and Persistence**

The college experience is a key juncture for women of colour in the STEM pipeline. Learning from minority women within the contexts of different institutional settings may illuminate those experiences, relationships and environments that contribute to their persistence in STEM fields of study, and onward into scientific careers. Private liberal arts college, more specifically coeducational liberal arts colleges, women’s colleges and historically Black colleges and universities (HBCUs), have proved effective in promoting persistence in STEM for women and form the basis for selection in this study (Rine, 2014; Griffith, 2010). Understandably, some within each category may be more effective than others.

**Private Liberal Arts Colleges.** Small liberal arts colleges are known for the attention and focus that is invested in its undergraduate education programs, and demonstrate more success in retaining undergraduates is STEM (Rine, 2014; Griffith, 2010; Espinosa, 2011; Chen & Soldner, 2013). Liberal arts colleges are predominantly private, coeducational White institutions with student enrolments averaging less than
2000 undergraduates (NAICU, 2016). Unlike large research universities, small liberal arts colleges, by the very nature of their size and mission, encourage close interaction between faculty and students, stimulate educational achievement and often provide earlier research opportunities for undergraduates (Pascarella & Terenzini, 2005; Huang et al., 2000). Seifert and colleagues (2010) determined that for students who enter college with significant challenges due to their family background and academic preparation, liberal arts colleges may offer more opportunities for student success. Espinosa (2011) found that for minority women, attendance at a private college increased their likelihood of completing their degree in STEM by nearly ten percentage points. She suggests that this success “can be attributed to the resource-rich environments that private institutions are able to construct for their students” (p. 231). Yet, her study concluded that attendance at a highly selective college was negatively associated with STEM persistence. The different levels of success found by URM female students in STEM, and the different types of colleges that provide that success, point to the realisation that institutions do matter (Malcom & Malcom, 2011).

Women’s Colleges. Women’s colleges in the United States grew out of the 19th century’s need to provide higher education opportunities for women who were denied admittance to universities that catered to a predominantly male population. While today, only 2% of female college students will graduate from a women’s college (Kinzie, Thomas, Palmer, Umbach & Kuh, 2007), a disproportionate number of women at these single gender colleges pursue post-graduate studies in STEM fields (Wolf-Wendel & Eason, 2011). President Jane Dammen McAuliffe of the all-female Bryn Mawr College stated that “women are still as least twice as likely to major in a STEM field at a women’s college than at a co-ed institution” (Steinberg, 2010). Hanson (2004) suggests that women’s colleges are particularly effective in encouraging the academic success of
women of colour in science. There is clear evidence that attending a women’s college facilitates some level of educational advantage.

Riordan (1994) suggests that women who graduate from these single gender colleges successfully acquire greater forms of education enhancing capital through a positive exchange of social capital as these tertiary environments are less prone to the effects of sexism more prevalently found at coeducational institutions. Although not specific to STEM concentrations, students at women’s colleges appear to display a greater commitment to student learning and academic involvement, deeper student-faculty interactions, an engagement in higher order thinking skills and open dialogue on issues of diversity compared to students at coeducational institutions (Smith, Wolf & Morrison, 1995; Kinzie et al., 2007). Kinzie et al. (2007) also postulate that women’s colleges provide more opportunities for students to engage cross culturally and are effective at producing campus conversations centred on issues of diversity. Women’s colleges have proportionally more female faculty and as such, offer greater opportunities for mentoring relationships (Miller-Bernal, 1993). “Women’s colleges are among the most empowering environments wherein women are taken seriously and ultimately experience success” (Wolf-Wendel & Eason, 2011, p. 157).

Women’s colleges are important producers of future scientists. In their analysis of the baccalaureate origins of recent (1995-2004) mathematics and science doctorates, Stage and Hubbard (2008) determined that the top-three liberal arts colleges that produced the greatest number of women scholars earning Ph.Ds. in engineering, mathematics and science were each a women’s college. Five women’s colleges appear in the top-ten list of the baccalaureate origins of female STEM doctorate recipients, and 56% of the female STEM doctorates who attended one of these ten institutions attended a women’s college. Additionally, Solorzano (1995) reported that women’s colleges that
were also HBCUs produced a significantly high number of African American women who received PhDs in science and engineering.

Rayman and Brett (1995) suggest that women’s colleges provide educational and social environments that promote resiliency and potential benefit for women in STEM, and graduates of women’s colleges display high retention rates in post-college STEM career paths. However, there are very limited research studies that explore the impact of women’s colleges on STEM degree attainment for URM women (Espinosa, 2009) and there still remains much to learn about the practices of this distinctive single-gender higher education environment (Wolf, 2000; Kinzie et al., 2007).

**Historically Black Colleges and Universities.** Historically Black Colleges and Universities (HBCUs) are higher education institutions established before 1964 and whose key mission is to educate Black Americans. HBCUs may be public or privately affiliated, either single-gender or coeducational. While only 14% of Black college students in the United States are enrolled at an HBCU (NCES 2004-062), 30% of all STEM bachelor’s degrees earned by Black students were awarded by an HCBU (Perna et al., 2009). Based on data from the National Center for Science and Engineering Statistics, Fiegener and Proudfoots (2013) report that the baccalaureate origins of the top 10 colleges producing Black science and engineering doctorates from 2002-2011 were all HBCUs. Extending that list to the top 50 baccalaureate producers of Black science and engineering doctorates, 21 were HBCUs.

Historically, HBCUs are successful producers of Black females into STEM careers. Gasman (2011) reported that fifty percent of the Black female students who matriculated into post-graduate science courses graduated from either Bennett College or Spelman College, both all-female HBCUs. Solorzano (1995) found that between 1980 and 1990, HBCUs were significant producers of Black female doctorates in
STEM. When determining the top fifty baccalaureate producers, thirty were HBCUs. Xavier University, a coeducational HBCU, is the single largest producer of Black female post-graduate medical students (Gasman, 2011). While these statistics may be impressive, “little is known about the ways that HBCUs promote the attainment of Black women in STEM fields” (Perna et al., 2009, p. 6).

Yet, it is clear that HBCUs appear to be effective in boosting the educational attainment for students of colour in STEM (Kim & Conrad, 2006). Students at HBCUs report higher levels of social support that reduce barriers leading to persistence in engineering, and women note receiving more social support than men. Compared to Black students at principally White institutions (PWIs), students at HBCUs enjoy higher levels of STEM related career goals, higher self-efficacy, and greater scientific interests (Lent et. al, 2005). Cokely and Chapman (2008) determined that for students attending an HCBU, positive alignment with ethnic identity affected academic self-concept, which in turn had a positive effect on GPA, though anti-White attitudes negatively impacted GPA. While the environment at HBCUs may be sensitive towards issues of racial equality, URM students are not completely immune from the effects of racism while attending an HBCU (Chavous, Harris, Rivas, Helaire & Green, 2004). Additionally, research studies focusing specifically on racial matters within the context of HBCUs may neglect issues surrounding gender, which can appear “swept under the rug”, as prior studies at HBCUs have concentrated more on male students (Gasman, 2011, p. 125).

In their case study which focused exclusively on female African American students in STEM at Spelman College, Perna et al. (2009) found that this unique institution fostered an environment that worked diligently to overcome the psychological barriers and inadequate support systems that typically plague campuses
that are ineffective in retaining female STEM talent. These researchers revealed that women at Spelman chose to attend this college because of its known reputation for supporting women in STEM. They determined that reduced class sizes, peer support, faculty encouragement and accessibility, opportunities to engage in research, tutoring and other academic support services, as well as STEM specific programs all contributed to persistence in STEM for African American women. Additionally, Perna and her team (2009) recommended that future research should focus more on how peer cultures at different types of institutions affect and influence STEM retention for URM women. However, one obvious detriment to persistence noted in this study, and also a potential area of future research, was the lack of adequate financial aid for financially needy students.

**Impact of Financial Aid**

With the rising cost of tuition and fees associated with pursuing an undergraduate degree in the United States, socioeconomic status can be a barrier preventing access to and persistence in STEM (Fenske, Porter & DuBrock, 2000). In recent years, financial aid programs have made a shift from grant aid to self-help (loans) aid which in turn may produce a heavy debt-burden for students at graduation (Tierney, Venegas & De La Rosa, 2006). For many students, the thought of assuming substantial educational debt may create a psychological burden, steering them towards careers requiring less education (E. Field, 2009). Many underrepresented minority students and students from lower socio-economic groups require significant financial aid in order to attend college and the provision of adequate financial aid packages can influence college enrolment patterns (Van der Klaauw, 2002). Receiving adequate financial aid significantly influences the likelihood that students of different racial and
socioeconomic backgrounds will complete their STEM degree (Hurtado, Clayton-Pederson, Allen & Milem, 1998; Huang et al., 2000; Foltz et al., 2014).

For private colleges, a large portion of grant (no-loan) aid comes from college endowment funds, so for many colleges there is a limited pool of available financial aid resources. Due to this financial constraint, only a select group of colleges are able to meet a student’s complete financial need, and students from lower socioeconomic groups and their parents often lack the knowledge to sort through and make sense of the various financial aid offers presented to students (Perna, 2006). “A sociocultural understanding of affordability is essential to understanding the college cost deliberations of low-income African American and Latino students and their families. Habitus shapes and informs college affordability decisions for students and their families” (McDonough & Calderone, 2006, p. 1703). For some women of colour and their families, a perception of the lack of affordability may block access in pursuing a STEM degree program. Or debt burden may preclude a student from completing a STEM program once already matriculated. However, colleges that offer substantial financial aid packages to talented URM students are more likely to not only recruit these students but to retain them as well (Huang et al., 2000; George, Neale, Van Horne & Malcolm, 2001).

**Summary of Literature Review**

Existing scholarly work points to the need to further understand how the undergraduate experience of URM women in STEM shapes and influences their persistence (Ong et al., 2011). The literature paints a clearer picture on the reasons why women of colour leave the sciences – ethnic isolation, chilly climate, SES, poor academic preparation, lowered academic expectations, diminishing academic self-
concept, lack of role models and mentors, and lack of recognition by others as someone with scientific potential; yet removing those barriers for minority women in STEM doesn’t necessarily guarantee persistence. The literature bears less clarity when surveying the landscape of why underrepresented minority women actually persist in STEM – family support, positive ethnic identification and community support, strong academic self-concept, undergraduate research experiences, financial aid, supportive mentors, and academic preparation may each be factors that pave a pathway towards persistence. “Undergraduate education marks the first point of entry into the post-secondary pipeline and influences career aspirations, making it essential to further explore how colleges and universities can best support women of colour pursuing STEM majors” (Ong et al., 2011, p. 198). While the current literature indicates more positive outcomes for women in STEM who attend smaller liberal arts institutions versus larger public institutions, there is a clear gap in the literature on how specific institutional types provide the environments and shape the experiences that lead to persistence for URM women in STEM. Mullen (2010) suggests that future studies should focus on the cultural settings within particular educational institutions and the experiences of URM women themselves. Harper (2010) suggests that studies exploring URM students in STEM adopt an anti-deficit approach, focusing more on why students succeed and less on why they fail. Additionally, Pascarella and Terenzini (2005) encourage studies which offer meaningful insight into “between-college” effects with measures reflective of institutional cultures and campus sub-environments (p. 634). In their synthesis of the current literature, Ong et al. (2011) call for more research on women of colour in STEM at HBCUs and other unique higher education institutions (such as women’s colleges) as very few studies exist which explore these specific academic and social college environments and their impact on persistence. At present,
there appears to be a reduced body of literature whose research comparatively analyses the overall college experience of URM female students who are persisting in STEM at different types of college campuses. Therefore, this study may potentially reduce the notable gap within this field of academic research.

**Theoretical Frameworks**

The next section of this chapter explores theoretical frameworks considered applicable to the study of URM female STEM students within a college setting. In particular, identity theory, college socialisation impact models and theories of cultural and social capital are discussed. Although a large body of research exists on the retention and persistence of students in a university setting, less is known about the specific theoretical influences that affect retention for students from culturally diverse backgrounds (Museus & Quaye, 2009), and more specifically URM female students studying and preparing for future careers in STEM.

Even in an environment that may not be welcoming or even female-friendly, minority women engage with, and “thrive in science” (Carlone & Johnson, 2007, p.1188). Yet, women of colour who choose the STEM path often have to conform to the norms of a scientific community that favour a culture steeped in White masculine values, a community in which they had no hand in shaping, and one that diverges from their prior educational experiences and valued social structures. Xie and Shauman (2003) suggest that the male gender composition of science and engineering cohorts inform women’s judgment of the appropriateness of those fields, hence inhibiting women from considering a STEM field of study. So what are the mediating influences that shape the identity of women of colour who choose to pursue a science or engineering path, and how might the college experience and college environment
influence persistence on that path? In this next section, three theoretical tenets that frame this study are discussed: identity theory, a model on college socialisation, and theories of cultural and social capital. A conceptual model reflective of the theoretical frameworks and guiding research questions is also discussed.

**Identity Theory.** Researchers have looked to identity theory as a lens to frame their understanding of women who persist in science. Exploring the intersection of race and gender, Tate and Linn’s (2005) qualitative study considered how identity affected campus engagement for female minority engineering majors. Through employing a *multiple identities* framework, these researchers sought to expand the concept of identity to include the cross-categorical effects between “academic, intellectual and social” (p. 485) aspects of identity. This framework provided a perspective in which to explore the complexities of student experience and their preliminary findings suggest that “academic achievement anchors student identities” (p. 491).

Expanding the notion of social identity to further encompass racial and ethnic considerations, Ong, Phinney and Dennis (2006) concluded that students who strongly connected and identified with their ethnic background experienced positive academic achievement. By utilising the *Multiethnic Identity Measure - MEIM* (Roberts et al., 1999), these researchers found that high scores on this scale correlated positively with high GPA (grade point average) in college. Through investigating the role of ethnic identity at a historically Black college (HBCU), Cokley and Chapman (2008) established that students who exhibited a strong ethnic identification possessed a positive academic self-concept which in turn translated into increased academic grades. However, research examining the effect of racial and/or ethnic identity on the academic outcomes of African American students has produced mixed results - results spanning the spectrum from positive influences (Chavous et al., 2003; Spencer, Noll, Stoltzfus &
Harpalani, 2001), to nominal influences (Lockett & Harrell, 2003) to even non-existent influences (Awad, 2007). Probing the role of racial identity in the academic outcomes of a cohort of African American students in a large urban, predominantly Black high school, Fordham (1988) found that students who desired to achieve academically had to abandon aspects of their culture in order to garner success. Yet narrowly filtering academic achievement through the lens of identity may only offer limited insight. Research needs to focus beyond the constraints of achievement in order to gain a greater understanding of why some students persist in science and others do not (Carlone and Johnson, 2007). What these studies do highlight though is the importance of the educational environment and situated context in the study of identity.

The construction of identity, both academic and ethnic, can be seen as a dynamic process that emerges through the various social practices and environmental settings in which a student engages (Nasir & Saxe, 2003). In recent years, James Gee’s theory on identity (1999, 2000) has enlightened a variety of studies on science identity explored within the context of a minority student population (B. Brown, 2004; Carlone & Johnson, 2007; Ceglie, 2011). Gee offers a description of identity as the “the ‘kind of person’ one is seeking to be and enact in the here and now” (1999, p. 13) as well as the “the ‘kind of person’ one is recognized as being, at a given time and place” (2000, p. 99). Identity is not solely based on self-perception, but is also influenced by the perception of how one is seen by others (Carlone & Johnson, 2007; Ceglie, 2011).

Looking more specifically at the intersections of gender, racial and ethnic identities, and how those aspects of identity affect the formation of a science identity specifically for women of colour in STEM, Carlone and Johnson (2007) developed a grounded theoretical framework to aid in the understanding of “the multiple ways that women of colour experience, make meaning of, and persist in science” (p. 1189).
Carlone and Johnson’s model, which relies on the socially constructed nature of science identity, is comprised of three overlapping spheres (performance—the ability to engage in scientific talk and use scientific tools; recognition—the ability of both seeing oneself and being seen by others as a person with an affinity for science; and competence—the ability to know and understand a body of science related knowledge) and the forces enacted upon those spheres by racial, ethnic, and gender identities (see Figure 2).

![Grounded model of science identity](image)

*Figure 2. Grounded model of science identity, Carlone and Johnson (2007)
Reprinted with permission from John Wiley & Sons, Inc.*

While these interconnected spheres exert normative influence in the formation of science identity, these researchers note that as they tested the model, the recognition component unfolded as the most meaningful in shedding light on the interaction of race, ethnicity and gender within the construct of science identity. Developing a sustainable science identity pivots critically on the recognition and affirmation from others as someone who possesses a talent for science. Carlone and Johnson’s framework was
developed over a six year period via ethnographic interviews conducted with fifteen women of colour who had each persisted on the science path. Their analysis yielded three different science identities (*Research Scientist Identity* – women who are stimulated by science knowledge, interested in studying the natural world and science for science’s sake; *Altruistic Scientist Identity* – women who use science knowledge and skills as a means in helping humanity; *Disrupted Science Identity* – women who felt marginalized by meaningful others within science though still pursue science career). Carlone and Johnson (2007) also note the dynamic nature of their model as women may possess the ability to renegotiate themselves into different identity directions based on circumstantial changes in their lives over the course of time. As women continue along the STEM pathway, future academic and workplace opportunities may elucidate the malleability of science identity within this framework.

**College Impact Models.** For college students, self-perceived identities are often shaped through the experience and exchange of interpersonal relationships within the context of the college setting. “Without allowing students to express their felt identities and place them in an appropriate context, researchers may overlook some of the nuances of the college experience and its consequences for the individual” (Kaufman & Feldman, 2004, p. 468). Throughout the college experience, students not only focus on preparing for possible future career paths but must also negotiate the socialisation process that occurs within the institutional culture of the college they attend. Building upon Brim and Wheeler’s (1966) definition of socialization as “the process by which persons acquire the knowledge, skills and dispositions that make them more or less effective members of society” (p. 3), Weidman (2006) developed a college impact model (see Figure 3) that explores the socialisation process of students in higher education, taking into account both individual and institutional effects. This framework
is similar to Weidman, Twale and Stein’s (2001) model on graduate student socialisation and extends Weidman’s (1989) earlier model which was also influenced by other existing college impact models (Astin 1977, 1984; Pascarella, 1985; Tinto, 1975).

Weidman’s (2006) model (see Figure 3) concentrates on both the internal and external environments that are linked to the college experience, and focuses upon the socialisation of students within a higher education context, allowing for both cognitive and non-cognitive outcomes. This framework encompasses non-linear processes that are interactive and dynamic, and begins when students enter college with certain aspirations, family background traits, and prior educational preparation. As students engage on their college campuses, they encounter the normative influences of peer groups and faculty relationships in relation to the socialisation practices of integrating into life on campus while also engaging within a community of learning. Throughout this college socialisation process, students are active participants as they evaluate and respond to the different normative pressures they face within the collective social and academic settings of their higher education environment. Weidman (2006) suggests that as students navigate the college experience, a socialisation process unfolds which in turn yields specific “knowledge, skills and dispositions” influencing student identity outcomes. Weidman’s model (2006) parallels Astin’s (1970a, 1970b) “input-environment-outcomes” framework whereby the input reflects the background characteristics of the student (family background, academic preparation, student aspirations), the environment denotes the structure and ethos embodied within the university context, and the outcomes embody the affective socialisation changes that the student experiences as a result of their university experience.

Weidman’s (2006) model is somewhat unique to other college impact models as it recognises the influence of professional and personal communities outside a student’s
higher education environment. Many families and communities maintain strong social ties with students even after students have left home to attend college. Additionally, professional communities may impact the socialisation of students through professional internships or work experiences. “Personal and professional communities often provide strong normative contexts for human social behaviour. Normative contexts are fundamental parts of higher education institutions’ organizational structure, and as such, play a key role in the socialization of students” (Weidman, 2006, p. 258). Instead of looking solely at the effective outcomes of these embedded social interactions, Weidman’s (2006) college impact model focuses more on the processes by which socialisation occurs within the paradigms of higher education.

![Diagram](image-url)

*Figure 3* Conceptualizing organizational socialization of students in higher education; Weidman (2006) Adapted from Weidman, Twale, & Stein (2001) Reprinted with permission from John Wiley & Sons, Inc.
Cultural and Social Capital. Within the context of higher education, cultural capital has been used as an critical lens and theoretical structure framing studies that have focused on relevant topics such as minority student retention (Tierney, 1999) and achievement within higher education (Cabrera & La Nasa, 2001). Bourdieu’s writings (1984, 1990) offer a comprehensive dialogue on educational environments and the social forces which may impact the development of cultural and social capital that is granted to students, concepts built upon the ideas of social reproduction and the perpetuation of educational inequities. Pertinent to Bourdieu’s theory of cultural capital is the concept of field which situates capital in a particular context or setting, allowing for the interpretation of the relevance of that capital. “Similar to the contextually-valued cultural capital interpretation, cultural capital in Bourdieu’s full theory of social reproduction includes the way in which one can appropriate cultural resources (including knowledge, skills, competencies, and abilities) toward a particular end” (Winkle-Wagner, 2010, p. 49). Contextually-valued and culturally situated interpretations of cultural capital suggest that “all people could have cultural capital, but it may or may not be valued in a particular context” (Winkle-Wagner, 2010, p. 29). Yet, in many educational research studies, students are deemed to either possess or not possess cultural capital based on their parents’ educational level, income and/or occupational status (Winkle-Wagner, 2010). In prior educational research, Perna (2000) and Wells (2008) extended this often used zero-sum argument of the possession of cultural capital by including quality of high school attended, college-going attributes of high school attended, peer group college-going values, and sources of encouragement and support to apply to college as indicators of educationally relevant capital. Exploring the parameters of cultural capital within an ethnically diverse student
population certainly requires a more wide-ranging understanding of how capital is framed (Aragon & Kose, 2007).

Yosso (2005) asserts that students of colour, by the very nature of their ethnically-rich communities, possess a type of cultural capital which she refers to as Community Cultural Wealth – “an array of knowledge, skills, and abilities utilized by communities of color to survive and resist macro and micro-forms of oppression” (p. 76). Yosso, similar to Bourdieau, recognises cultural capital as an asset to be used towards a particular end. However, her model of Community Cultural Wealth emphasises that the source of cultural capital is not limited to only those of high social status. Drawing upon Critical Race Theory (CRT) and grounded in resisting forms of racial oppression, Yosso (2005, p. 77-80) outlines six forms of capital students of colour may possess, develop and draw upon as they engage within an academic setting:

1. Aspirational capital: preservation of hope and future dreams despite opposition and barriers.
2. Linguistic capital: skills achieved through multi-linguicism.
3. Familial capital: cultural knowledge and intuition gained from ethnic kin and community.
4. Social capital: community based contacts, networks and resources that provide support in maneuvering through institutions.
5. Navigational capital: skills and ability to navigate through institutions in which the student does not belong to the institution’s predominant racial group.
6. Resistant capital: skills and knowledge acquired through experiencing inequalities in a social or organizational context.

While this model may focus on the forms of capital acquired outside of the academic milieu, it validates not only the strengths that students of colour bring with them into the classroom and learning environment (Yosso, 2005; Aragon & Kose, 2007) but also
provides keys to the sources of agency needed to acquire additional capital in an academic environment that might not be considered friendly to minorities (Horvat, 2001).

Tierney (1999) asserts that when students of colour are encouraged to embrace their cultural identities within a university or college context, they increase their probabilities of graduating. His model of Cultural Integrity emphasizes the need for students to find their academic fit within the various landscapes of their higher education setting while still affirming and maintaining their cultural identities, and clearly places the responsibility with institutions for increasing student success.

“Cultural integrity transfers the problem of educational inequity from the student to the institution and identifies cultural background as an essential element for academic success” (Tierney, 1999, p. 85). Tierney argues that schools and universities should “honor” and “accommodate” the differences that exist within an ethnically diverse student body (p. 83). Although some argue that educationally related capital is transferred primarily from parents, Tierney (1999) suggests that students can “learn” the cultural capital which other students have “inherited” in order to increase their successful progression through college (p.83).

While research studies have critiqued schools though exploring the notions of cultural or social capital, less is known about how educational institutions actually build student capital (Aragon & Kose, 2007). Thomas (2002) asserts that institutions may possess a habitus reflective of their missional values and institutional practices which in turn influences student persistence. In their recent case-study that assessed the effectiveness of cultural capital enrichment of underrepresented minority students in the sciences at UC Davis, Ovink and Veazy (2011) determined that “community-directed cultivation” is a worthy endeavour, and that “efforts towards expanding habitus and
thereby augmenting cultural and social capital may have positive effects for URM college students’ academic and career prospects” (p. 390). Consistent with Tierney (1999), Ovink and Veazy’s efforts explored interventions that increased URM STEM students’ knowledge and skills while still affirming and supporting students’ ethnic bonds within their cultural communities. Collectively, these researchers recommend moving the expectations for success away from the individual student and more towards a university context that adjusts to students’ cultural norms. Winkle-Wagner (2010) asserts that “this angle on cultural capital connects well with the otherized interpretations, shifting some of the focus away from understanding only those forms of cultural capital or habitus dominant in a particular field” (p. 57).

In addition to Yosso’s (2005) model of Community Cultural Wealth and Tierney’s (1999) model of Cultural Integrity, Stanton-Salazar (2011) offers a social capital framework in which institutional agents assume roles of empowerment for students. In order for students from under-resourced backgrounds to develop the social capital needed to negotiate their various educational demands and challenges, Stanton-Salazar (2011) suggests that “resourceful relationships” and “institutional agents” may provide access to an “array of resources, privileges and rewards” (p. 1069) for students. Extending Stanton-Salazar’s concepts to a college setting, institutional agents may be positioned as teachers, counsellors, mentors, advisors, research supervisors or professors “who enact a variety of roles, some focused on the process of directly providing key forms of institutional support while other roles focus on key forms of networking” (p. 1079). Stanton-Salazar further suggests that these institutional agents could additionally operate as “empowerment agents” when these relationships provide assistance to the student in acquiring the personal resources necessary to overcome institutional barriers through problem-solving strategies and networking skills. The
relationships formed within institutions and outside of families offer a platform from which education enhancing capital is acquired (Goldethorpe, 2007; Stanton-Salazar, 2011). Within a college context these resource rich relationships are often based upon a shared trust that encourages the strengthening of norms, which in turn facilitates the advancement of mutually beneficial goals (Coleman, 1988).

The path towards acquiring the education enhancing capital necessary for persistence in a college environment though, appears at best a bumpy one for minority students. As Ovink and Veazey (2011) observe, “… the accumulation of education-enhancing cultural capital and the formation of positive social ties that aid college attainment are more difficult for working class and/or minority students” (p. 374).

Exploring the sources of both cultural and social capital for underrepresented minority women in STEM may offer a depth of insight towards understanding those resources that not only empower these women but also reduce the inequities often experienced in the STEM academic setting.

**Conceptual Model**

Based on a synthesis of the current literature, and shaped by the theoretical frameworks discussed earlier in this chapter, a conceptual model for this study was developed that represents the multidimensional factors considered as influential towards the persistence of URM women in STEM fields of study set within the context of a liberal arts college setting (see Figure 4). Each category in this conceptual model relates specifically to the guiding research questions developed for this study. This model relies upon theories of identity, college impact models, and theories of cultural and social capital (see Figure 4).
IDENTITY
Science Identity:
- Performance
- Competence
- Recognition
Ethnic Identity:
- Ethnic Identity Exploration
- Ethnic Identity Commitment

PRE-COLLEGE BACKGROUND
Academic Preparation
Quality of High School
Aspirations
Inherited Cultural Capital
- Parental
- Socialisation
- Institutional Agents

HIGHER EDUCATION INSTITUTIONAL CONTEXT
College Environment
- Racial Climate
- Academic Belonging
- Campus Commitment to Diversity
College Experiences
- Extracurricular Involvement
- Academic Stamina
- Competition in STEM
- Achievement/GPA
Resourceful Relationships
- Faculty
- Advisors
- Peers
Supportive Resources
- Financial Aid
- Academic Support
- Acquired Social Capital
- Acquired Cultural Capital

INFLUENTIAL OTHERS
Professional Mentors
Research Supervisors
Internship Supervisors
Parents
Families/Community

OUTCOME
Persistence in STEM

Figure 4. Conceptual model: Factors that promote persistence for undergraduate URM women in STEM in a liberal arts college setting
This conceptual model (see Figure 4) first considers a student’s Pre-College Background; included within this domain are a student’s academic preparation through rigorous STEM course taking in high school, the quality of high school attended, parental and peer aspirations, and consideration of a student’s inherited cultural capital upon college entry. Although prior research studies have operationalised student cultural capital based upon parents’ income, education and occupation (Winkle-Wagner, 2010), this model extends these parameters to include capital accessed through agents outside the family (Perna, 2000; Wells, 2008). For women of colour to persist towards a degree in a STEM field of study, the family may not be the only source through which cultural capital is acquired (Goldethorpe, 2007). This study also considers the capital acquired through students’ interactions with institutional agents both during school and into college (Tierney, 1999; Stanton-Salazar, 2011). Based upon this model, Pre-College Background directly influences a URM female STEM student’s Identity, her experience within the Higher Education Institutional Context and ultimately, her persistence in STEM. Central to this conceptual model is the Higher Education Institutional Context or what Weidman (2006) refers to as “Higher Ed Institution’s Normative Contexts and Socialization Processes” (p. 257) and expands Weidman’s conception in that this model explicitly considers additional issues of racial climate, diversity, financial aid and social and cultural capital acquired within the milieu of the campus experience, all considered pertinent to the success of students of colour. Within the central domain of the Higher Education Institutional Context, four specific areas are highlighted for consideration: College Environment; College Experiences; Resourceful Campus Relationships and Supportive Resources. Within the parameters of College Environment are campus racial climate, a student’s sense of academic belonging, and a campus’ commitment to diversity. Related to College Experiences are students’ co-
curricular involvements which may include involvement in, but not limited to, academic organizations, diversity events and/or organizations and research experiences. Additionally, also considered are academic stamina, the experience of varying levels of competitiveness in STEM and academic achievement/GPA. The third component within the *Higher Education Institutional Context* is the Resourceful Campus Relationships students experience with faculty, advisors, campus mentors and peers (Stanton-Salazar, 2011). The fourth and final component within this domain are the Supportive Resources a student acquires, uses or accumulates during her time in college which include adequate financial aid, formal academic support programs, and social capital and cultural capital acquired during college. Weidman’s (2006) model considers capital such as knowledge, skills and dispositions as personal outcomes of the “normative contexts and socialisations processes”. However, in this conceptual model, cultural and social capital acquired throughout the college process are seen as instrumental in student persistence in STEM, and thus are determined as an input on which persistence is dependent. Each of the four components within the *Higher Education Institutional Context* outlined in this conceptual model work simultaneously to define the overall college experience for women of colour in STEM.

Pertinent to this conceptual model is also the role of *Influential Others* in the lives of URM female STEM students. Those considered as *Influential Others* would include professional mentors, research supervisors, internship supervisors, parents and family and extends those whom are represented in Weidman’s (2006) Personal Communities. This conceptual model proposes that the impact of *Influential Others* affects student *Identity*, a URM female STEM student’s experience within the *Higher Education Institutional Context* and her *Outcome* of persisting in STEM.
Essential to this model is *Identity* which is, for this study, informed by two different constructs of identity – Science Identity for women of colour (Carlone & Johnson, 2007) and Ethnic Identity as measured by the Multiethnic Identity Measure (MEIM) (R. Roberts et al., 1999). *Pre-College Background* and *Influential Others* are seen as mediating influences on *Identity*. This model suggests bi-directional influences between *Identity* and *Pre-College Background, Higher Education Institutional Context, and Influential Others*. In this model, *Identity* indirectly influences the *Outcome* of persistence in STEM as *Identity* may be shaped through the influences of the overall college experience.

**Research Questions**

The conceptual model for this study (see Figure 4) was developed after a careful synthesis of the current research literature on URM women in STEM, in addition to an analysis of pertinent theoretical frameworks related to the persistence and retention of URM female STEM students in higher education. Motivated by this conceptual model, the main research question for this study emerged as: What factors promote persistence in STEM for underrepresented racial minority women who attend different types of liberal arts colleges (women’s, coeducational, HBCU) in the United States? Directly related to the main research question, and as listed below, five guiding questions were constructed in order to more explicitly explore different facets within this conceptual model that also expand the main research question.
Guiding Research Questions:

1. What aspects of pre-college background and inherited cultural and social capital provide the competencies necessary for persistence for women in STEM?

2. In what ways do college experiences, college support structures, perceptions of campus environments and resourceful campus relationships differ for URM and non-URM women who persist in STEM and how do these measures differ for URM women at different types of colleges?

3. How do campus environments and ethnic identity affect the acquisition of cultural capital for URM women who persist in STEM and do prior levels of “inherited” cultural capital affect measures of “learned” capital acquired during the college years?

4. Do campus environments and measures of acquired cultural and social capital affect the formation of science identity for URM women who persist in STEM at a liberal arts college?

5. In what ways do parents, external mentors and other resourceful relationships influence URM women’s continued persistence in STEM?

The next chapter presents the methodology which explores these five guiding questions. A description of the setting and participants, and how they were recruited to the study are also discussed. Additionally, the next chapter also presents a discussion on the relevant research design and research instruments employed in this study, the validity and reliability of those instruments, and the methods by which the data for this study were analyzed.
Chapter 3: Methodology

The purpose of this study is to gain a better understanding of how the organisational environment and social practices experienced at different types of liberal arts colleges in the US affect the persistence of URM women in STEM fields of study. Using a mixed-methods research design, this study explored the experiences of female STEM students at five private liberal arts colleges that had each demonstrated an outstanding track record of graduating women in STEM. In the context of these various college settings, and as guided through the lens of the conceptual model, the research questions posed for this study were explored in order to discover if these “best-case” occurrences of graduating high numbers of women in STEM extended as well to URM women on these campuses, and if so, how.

This chapter begins with a discussion on the relevance of the mixed-methods research design chosen for this study, a description of the setting and participants, and a detailed explanation of how the institutions and participants were recruited to the study. After discussing the positionality of the researcher, this chapter then describes both the quantitative and qualitative instruments used in the study, and the validity and reliability of those instruments. The chapter further discusses how the data was processed, more specifically how missing data was handled, how scales were developed through factor analysis, and how an indexed variable for science identity was constructed. The chapter then explores the methods by which the data were analysed. Each research question was used as a guide and the statistical methods employed to analyse the quantitative data are clearly shown in relationship to the particular research question posed. Additionally, the method of measuring effect size for this study is discussed. The chapter closes with a
discussion on the overall validity and reliability of the research design, and an
assessment of the ethical considerations and the perceived limitations of this study.

**Research Design**

This study followed a convergent parallel mixed-methods design (Creswell &
Clark, 2007). Both quantitative and qualitative data were collected simultaneously
within the context of a campus environment. Convergent design allows the researcher to
“obtain different but complementary data on the same topic” (Morse, 1991, p. 122).
This particular mixed-methods research design also allowed for quantitative results to
be further clarified by qualitative findings and for qualitative results to be further
explained through quantitative data analysis. Additionally, mixed-methods design also
allowed for triangulation of the data. The analysis of both the quantitative and
qualitative data was contextualised within the construct of the particular higher
education environment in which it was situated as this study sought to explore both the
student experiences and the higher education environments that encouraged persistence.

**Setting and Participants**

The participants in this study were female undergraduate students who had
completed at least two years of study in a STEM field, and who attended one of the five
U.S. liberal arts colleges selected for this study. Students in STEM who persist into their
third year of study usually display a high rate of degree completion (Grandy, 1998).
Although this study’s primary focus concentrated on the experiences of URM female
STEM students who persist in STEM, for the purposes of comparative analysis, female
STEM students of all racial backgrounds were sought as participants. This stratified
purposeful sampling of students allowed for the ability to describe the subgroup of
URM women in particular depth (Patton, 2002).
Institutional Sample

Data was collected at five different private colleges in the United States: two women’s colleges, two coeducational liberal arts colleges and one HBCU. As this study focused on factors that promoted persistence for URMs in STEM fields of study, choosing colleges to participate in this study that had a proven track record of graduating successful women in STEM seemed logical and appropriate (Museus & Liverman, 2010).

Colleges that produced a high number of female STEM scholars were sought for this study. Stage and Hubbard’s (2008) published baccalaureate-origins list was used as a guide for seeking suitable higher education institutions for participation in this study, as this list highlights the top ten liberal arts colleges in the U.S. that produced the highest number of women scholars earning PhDs in STEM from 1995-2004. Interestingly, four of the top five top colleges on this list are women’s colleges. All of the ten colleges on this list were contacted for participation in this study.

As this baccalaureate-origins list of women STEM scholars did not include any HBCUs, an alternative route was sought to identify HBCUs for this study. The potential participating HBCUs for this study were selected based on their inclusion in Fiegener and Proudfoot’s (2013) baccalaureate-origins list of the 50 colleges/universities that produced the most Black science and engineering doctoral graduates from 2002-2011. This list included both PWIs and HBCUs. Apart from race, this list was not delineated for gender. Of the 20 HBCUs represented on that list, five were contacted for participation in this study.

An introductory letter outlining the purposes of this research study was sent to each of these 15 (five women’s, five coeducational, five HBCUs) colleges’ Office of Institutional Research seeking permission to survey and interview their female STEM
students. Of the 15 colleges contacted, five colleges agreed to participate in this study (two women’s, two coeducational and one HBCU). Each college’s Office of Institutional Research identified and assigned a local faculty sponsor to assist with logistics of site visits as well as with the ethics documentation and application required by each Institutional Review Board (IRB). The next chapter highlights key institutional characteristics of each of the five participating colleges in this study, as well as provides a detailed description of the academic and ethnically-based programs offered to URM female STEM students on each campus. Due to confidentiality, each of the participating colleges has been assigned a pseudonym. Women’s colleges begin with a “W” (Whitt; Woodard), coeducational colleges begin with a “C” (Cahill, Cresswell) and the HBCU begins with an “H” (Hayden).

**Recruiting Participants**

After ethics approval was granted at each institution, an email invitation was sent to female STEM students at each college who had completed at least four semesters towards their degree. This invitation outlined the research objectives of the study, the name and contact information of this researcher, the name and contact information of the college’s faculty sponsor and the name and contact information for the college’s Institutional Review Board (Ethics committee) liaison. Student participation was completely voluntary. At four of the five colleges, students were offered a participation incentive of being included in a prize draw for an Amazon gift or gift card (value $100USD). One of the participating colleges did not advocate incentives, so none were offered to those particular participants.

After removing responses from students who did not identify their racial background or adequately complete the survey, this purposive stratified sampling plan
across the five colleges yielded a sample of $N=447$ female STEM student participants ($n=94$ URM, $n=353$ non-URM). Table 2 organises the participants by racial/ethnic grouping and college type.

Table 2

*Female STEM Participants’ Race/Ethnicity and College Type*

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Asian</th>
<th>Black</th>
<th>Hispanic</th>
<th>Native American</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women’s College Participants</td>
<td>163</td>
<td>66</td>
<td>17</td>
<td>22</td>
<td>2</td>
</tr>
<tr>
<td>Coeducational College Participants</td>
<td>113</td>
<td>11</td>
<td>14</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>HBCU Participants</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Participants</td>
<td>276</td>
<td>77</td>
<td>51</td>
<td>40</td>
<td>3</td>
</tr>
</tbody>
</table>

*Note:* Total sample size $N=447$ ($n=353$ non-URM; $n=94$ URM)

URM female STEM students who completed the online survey were also invited to participate in a one-to-one, face-to-face, on-campus interview. In order to maintain anonymity of survey responses, at the conclusion of the survey, students were redirected to a different webpage that noted the selection criteria for interviews (Female STEM student, an underrepresented minority student, completion of at least 4 semesters towards a STEM degree). Students who believed they met the criteria and desired to participate in an interview submitted their contact details and were then contacted by the researcher to determine a convenient on-campus interview location and time. From this pool, 34 students were interviewed; yet only 30 were included for analysis as it was discovered during the course of the interviews that four students had not met all of the interview criteria. All interviewed participants were offered $25 for their time. Table 3 highlights the background of each of the interviewed participants.
Table 3

*Background of Interviewees (n=30)*

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>College</th>
<th>Ethnicity</th>
<th>Major</th>
<th>Mother’s Occupation</th>
<th>Father’s Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Cahill</td>
<td>Latina</td>
<td>Engineering</td>
<td>Economist</td>
<td>Engineer</td>
</tr>
<tr>
<td>C2</td>
<td>Cahill</td>
<td>Black</td>
<td>Engineering/Business</td>
<td>Sociologist</td>
<td>Teacher</td>
</tr>
<tr>
<td>C3</td>
<td>Cahill</td>
<td>Black</td>
<td>Engineering/Business</td>
<td>Teacher</td>
<td>N/A</td>
</tr>
<tr>
<td>C4</td>
<td>Cahill</td>
<td>Black</td>
<td>Engineering/English</td>
<td>Office Worker</td>
<td>Pastor</td>
</tr>
<tr>
<td>C5 *</td>
<td>Cahill</td>
<td>Latina</td>
<td>Engineering</td>
<td>Unemployed</td>
<td>Sanitation Worker</td>
</tr>
<tr>
<td>C6</td>
<td>Cahill</td>
<td>Latina</td>
<td>Biology</td>
<td>Teacher</td>
<td>Gov’t Worker</td>
</tr>
<tr>
<td>W1</td>
<td>Woodard</td>
<td>Latina</td>
<td>Biology/Anthropology</td>
<td>Banker</td>
<td>Business</td>
</tr>
<tr>
<td>W2</td>
<td>Woodard</td>
<td>Latina</td>
<td>Astrophysics</td>
<td>Teacher</td>
<td>N/A</td>
</tr>
<tr>
<td>W3</td>
<td>Woodard</td>
<td>Black</td>
<td>Neuroscience</td>
<td>Business</td>
<td>Chemist</td>
</tr>
<tr>
<td>W4 *</td>
<td>Woodard</td>
<td>Latina</td>
<td>Physics</td>
<td>Homemaker</td>
<td>Construction Worker</td>
</tr>
<tr>
<td>W5</td>
<td>Woodard</td>
<td>Latina</td>
<td>Astrophysics</td>
<td>Teacher</td>
<td>Business</td>
</tr>
<tr>
<td>W6 *</td>
<td>Woodard</td>
<td>Black</td>
<td>Biology</td>
<td>Homemaker</td>
<td>N/A</td>
</tr>
<tr>
<td>W7</td>
<td>Woodard</td>
<td>Black</td>
<td>Biology</td>
<td>Manager</td>
<td>Preacher</td>
</tr>
<tr>
<td>W8 *</td>
<td>Whitt</td>
<td>Black</td>
<td>Engineering/Econ</td>
<td>Unemployed</td>
<td>Bus Driver</td>
</tr>
<tr>
<td>W9 *</td>
<td>Whitt</td>
<td>Latina</td>
<td>Engineering</td>
<td>Cook</td>
<td>Welder</td>
</tr>
<tr>
<td>W10</td>
<td>Whitt</td>
<td>Latina</td>
<td>Astrophysics</td>
<td>Office Manager</td>
<td>Lawyer</td>
</tr>
<tr>
<td>W11 *</td>
<td>Whitt</td>
<td>Latina</td>
<td>Neuroscience</td>
<td>Pre-School Teacher</td>
<td>Office Manager</td>
</tr>
<tr>
<td>W12 *</td>
<td>Whitt</td>
<td>Latina</td>
<td>Biology</td>
<td>Waitress</td>
<td>Factory Worker</td>
</tr>
<tr>
<td>W13</td>
<td>Whitt</td>
<td>Black</td>
<td>Biology</td>
<td>Lawyer</td>
<td>N/A</td>
</tr>
<tr>
<td>W14 *</td>
<td>Whitt</td>
<td>Latina/Black</td>
<td>Computer. Science</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>W15 *</td>
<td>Whitt</td>
<td>Filipina</td>
<td>Biology</td>
<td>Payroll</td>
<td>Retired</td>
</tr>
<tr>
<td>W16</td>
<td>Whitt</td>
<td>Latina</td>
<td>Environmental Science</td>
<td>Economist</td>
<td>Economist</td>
</tr>
<tr>
<td>W17 *</td>
<td>Whitt</td>
<td>Latina/Black</td>
<td>Geology</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>H1</td>
<td>Hayden</td>
<td>Black</td>
<td>Biology</td>
<td>Education Specialist</td>
<td>Music Therapist</td>
</tr>
<tr>
<td>H2</td>
<td>Hayden</td>
<td>Black</td>
<td>Biology</td>
<td>Lawyer</td>
<td>Lawyer</td>
</tr>
<tr>
<td>H3</td>
<td>Hayden</td>
<td>Black</td>
<td>Biology</td>
<td>Educator</td>
<td>Construction Worker</td>
</tr>
<tr>
<td>H4</td>
<td>Hayden</td>
<td>Black</td>
<td>Chemistry</td>
<td>N/A</td>
<td>Admin Fire Dept.</td>
</tr>
<tr>
<td>H5</td>
<td>Hayden</td>
<td>Black</td>
<td>Biology</td>
<td>Retail</td>
<td>Accountant</td>
</tr>
<tr>
<td>H6</td>
<td>Hayden</td>
<td>Black</td>
<td>Biology</td>
<td>Teacher</td>
<td>Communication Technician</td>
</tr>
<tr>
<td>H7</td>
<td>Hayden</td>
<td>Black</td>
<td>Biology</td>
<td>Nurse</td>
<td>Military</td>
</tr>
</tbody>
</table>

*Indicates First-Generation College Student (neither parent completed university)

*a sub-ethnic group underrepresented in STEM (Sambrano, 2001)*

Positionality of the Researcher

In social science research, including in education, it is commonly important for
the researcher to note their own relationship to the particular setting in which their
research occurs, as well as their placement amongst research participants with respect to
their own race, culture, education and background (Milner, 2007). This reflection allows the researcher’s own narrative to inform the research study through reconstructing their positionality as a tool for understanding, and enables readers to take into account researcher position, in assessing their interpretation.

Although a generation removed from the participants in this research study, like many of the URM female students in this study, I grew up in an inner city neighbourhood in a family of low socioeconomic means. Attending a large urban high school in which less than 20% of students would pursue a college degree, I was also the first in my very large extended family to attend university. Not knowing about opportunities for financial aid, I enrolled at a large state university as it was the least expensive option for furthering my education. By the time of reaching my second year of college, I had learned of the opportunities for state and federal financial aid and then received sufficient funds to complete my degree. I intended to major in computer science, but as that was not an undergraduate option at my university I was placed in the School of Engineering. While this was a good fit for my academic gifting in mathematics, I had little understanding of what an engineer actually did and felt culturally out of place. Entering the workforce upon graduation, I was only one of a few female engineers employed at my particular global electronics company, and as such had to endure episodes of discrimination due to my gender.

After taking time off to raise a family, I re-entered the workforce as a secondary school mathematics teacher. In the decade prior to my enrolment in the PhD program, I worked at an all-girls independent school in which all of the students would go on to attend university, many at ivy-league colleges. The stereotype that “girls are not good at mathematics” was never one embraced in this setting, and many of my students would eventually major in physics, mathematics or engineering upon entering university. The
tuition and fees to attend this school made it one of the most expensive private day schools in the U.S. However, the school adopted a significant scholarship program for students of promise from disadvantaged backgrounds. In a mentoring capacity, I found myself drawn to many of the girls of colour and those from the lower rung of the socioeconomic ladder. In some ways, I saw glimpses of my own narrative reflected in their stories. Apart from my role as a mathematics teacher, I advised many students and families on the college admission process. I eventually split my time between teaching and college advising. During my last four years in this all-girls school, I was the Director of College Guidance, and worked passionately to assist students whose families had little knowledge of the financial aid or college admission process. My interest in studying the success of URM female students in STEM is linked inextricably to my own background as well as my desire to empower young women to strive towards their educational goals.

**Research Instruments**

As a mixed-methods study, both quantitative and qualitative data instruments were designed to facilitate data gathering. Female STEM students (URM and non-URM) participated in the study by completing an online questionnaire. Additionally, URM female STEM students were invited to participate in a semi-structured interview. Formal and informal observations, and college documents (college view-books, college websites, STEM specific brochures, and diversity focused materials) were gathered for content analysis to assist in the contextual discussion of the research results and were useful in understanding the mission and values purported by each liberal arts college and the various STEM departments and offerings within each institution. A more detailed analysis of the research setting is described in the next chapter.
Closed Questionnaire. The 87-item closed questionnaire used in this study was comprised of four distinct sections that assessed student background characteristics, levels of inherited and acquired cultural and social capital, ethnic identity and academic self-concept (see Appendix A). Section I (Prompts 1-28) of the survey contained items that focused on a student’s family, social and academic background, as well as prompts relating to pre-college cultural and social capital variables that were adapted from previous studies (Perna, 2000; Wells, 2008). In Section II (Prompts 29-54) students were asked to respond using a 5-item Likert-type scale (Strongly Disagree=1 to Strongly Agree=5) to items related to a student’s college experiences, perceptions of campus racial climate, perceptions of STEM classroom climate, sense of belonging in STEM, satisfaction with financial aid, and acquired cultural and social capital. Section III (Prompts 55-67) contained the Multi-group Ethnic Identity Measure: MEIM (R. Roberts et al., 1999). The MEIM offers an overall measure of ethnic identity with two subscales embedded within this instrument that offer measures for Ethnic Identity Exploration and Ethnic Identity Commitment. Use of the MEIM relates to the cultural capital construct of Cultural Integrity integral to the theoretical frameworks employed in this study (Tierney, 1999). The MEIM has been used frequently in the literature and has been found to offer both a reliable and valid scale to measure aspects of ethnic identity (Ponterotto, Gretchen, Utsey, Stracuzzi & Saya 2003; Worrell, 2000). For this study, the overall MEIM scale produced a respectable Cronbach’s alpha (α=.898), as did the subscales of Ethnic Identity Exploration (α=.775) and Ethnic Identity Commitment (α=.868). Section IV of the questionnaire (prompts 68-87) contained a Mathematics Self-Concept measure (even numbered prompts 68-86) and a Problem-Solving Self-Concept measure (odd numbered prompts 69-87) and was taken directly from the Self-Descriptive Questionnaire III (SDQ-III) (Marsh & O’Neill, 1984; Marsh, 1992).
Students responded to each prompt using an 8-item Likert-type scale (Definitely False = 1 to Definitely True=8). Negatively worded prompts were reverse coded. Used extensively, this scale has been validated in prior research (Byrne, 1988). For this study, the Mathematics Self-Concept Scale from the SDQ-III produced a Cronbach’s alpha of .900 and the Problem-Solving Self-Concept Scale yielded a Cronbach’s alpha of .778. These specific STEM related measures of academic self-concept were reflective of a student’s habitus and were used to measure the competence component of the theoretical construct of Science Identity that was explored in this study.

**Semi-structured Interviews.** The semi-structured interview format used in this study was adapted from the interview protocols developed by Perna et al. (2009) for their case study of women of colour in STEM at Spelman College, a women’s HBCU (see Appendix B). The interview questions probed college choice, career aspirations, the role of parents, family and other models, relationships with mentors and faculty, the college environment and experience with prompts for school culture, STEM classroom culture, faculty interaction, academic advising, academic clubs, social/diversity clubs, and internship and research experiences. Additionally, the student interview format contained specific questions relating to social networks, perceptions of racial discrimination, ethnic/cultural background, financial aid and student perceptions regarding persistence in STEM in the context of institutional climate and culture. For interviews that took place on coeducational campuses, there were additional prompts for students to be able to potentially discuss instances of sexism experienced on the campus or in the classroom. All interviews were digitally recorded and to ensure confidentiality, interview participants were assigned a pseudonym.
Data Processing and Analysis

Analysis of both quantitative and qualitative instruments occurred in tandem and addressed the specific research questions posed in this thesis based on the theoretical framework adopted for this study. Quantitative data generated from the questionnaires were uploaded directly into SPSS v. 22 from the online survey platform. Before analysis of the quantitative data could begin, a method for handling missing data in the survey was addressed, as well as a process for reducing survey data to create factors that related specifically to the posed research questions. Additionally, a process for determining an index score for Science Identity was constructed. After a multi-step transcription process, interview data was uploaded in NVivo v.10 for further analysis.

Handling missing quantitative data. Depending on the type of data missing, different methods were used in the imputation of missing data. Within the survey responses, eight students did not indicate their college GPA. These missing values were imputed based on college attended and SAT/ACT scores, which are often seen as a predictor of college GPA (Coyle & Pillow, 2008). When asked to indicate the range of their family’s income, 19% of students indicated either “don’t know” or left the prompt blank. These missing values were imputed based on parents’ education and ethnicity. Approximately 25% of students did not indicate their SAT/ACT university entrance exam scores. When asked to estimate the percentage of their high school graduation class that attended college, more than 20% of students indicated that they “didn’t know”. Therefore, the responses to both SAT/ACT scores and the percentage of high school graduation class that attended college were not used in any further analysis for this study as the threshold for imputation of missing values is commonly accepted as 20% (Peng, Harwell, Liou, & Ehman, 2006). For students who did not complete either the MEIM: Multi-Ethnic Identity Measure (n=5) or the Academic Self-Concept
Measures \((n=10)\), these students were not included in any analyses that used these measures, but their responses to other prompts were used in analysing data that excluded these measures. For those students who attempted to complete the MEIM and the Academic Self-Concept Measures, less than two percent of individual data points were missing. Missing values were imputed via SPSS v.22 using an Expectation Maximization (EM) algorithm.

**Development of scales.** Prompts from Section II of the survey directly related to students’ college experiences and for the purposes of data reduction and the development of appropriate scales to measure aspects of students’ college experience, and cultural and social capital acquired during college, the relationship between these prompts was investigated through Factor Analysis using Principal Component Analysis with Varimax (orthogonal) rotation with Kaiser Normalization (see Table 4).

Several well-established standards for the suitability of factorability were used. In the factor analysis conducted, the Kaiser-Meyer-Olkin measure of sampling adequacy was .836, above the minimum recommended value of .600. Bartlett’s test of sphericity was significant \(\chi^2(190) = 2841.190, p = .000\). Each item shared common variance with the other items as the communality values ranged from .391 to .826. The diagonals of the anti-image correlation matrix ranged from .736 to .912 indicating that all 20 selected items should be included in the factor analysis (see Table 4).

Based on the factor analysis conducted, specific factor scales were determined for Campus Racial Climate, Acquired Social Capital, Acquired Social Capital and Early STEM Academic Belonging. A Cronbach’s alpha coefficient of internal consistency was determined for each factor with an acceptable level set at \(\alpha=.700\) (George & Mallery, 2003). The Cronbach’s alpha for the Campus Racial Climate factor was .829. The Cronbach’s alphas for the factors of Acquired Social Capital and Acquired Cultural
Capital were .729 and .728 respectively. When three academic years were initially included in the Academic Belonging factor, the Cronbach’s alpha was measured at .670, below the recommended value of .700. Yet, upon removal of one of the three items associated with this factor (felt a sense of belonging in my junior [third] year), the Cronbach’s alpha measure of internal consistency for the STEM Academic Belonging factor increased to 0.722. However, with only two items assigned to this factor there was less interpretive meaning as an overall measure of academic belonging. This two item factor, which assesses a sense of academic belonging over the first two years of college, was considered more indicative of Early STEM Academic Belonging. The items suggested for the factor for Perseverance (α=.659) presented with only two items per factor lending minimal effect for data reduction and a Cronbach’s alpha below the acceptable level of .700. The two items suggested for the Diversity Efforts factor did not coincide with supporting theory. Hence, this factor was not used in this study.

In addition to defining scales for Racial Climate, Acquired Cultural Capital, Acquired Social Capital, and Early STEM Academic Belonging, a composite index score for Science Identity was determined based upon specific quantitative variables that reflected the three domains of “performance, competence and recognition” as outlined in Carlone and Johnson’s (2007) model of Science Identity for women of colour. Their qualitatively determined model was quantitatively operationalised in Espinosa’s (2009) study in which she created a quantitative scale for Science Identity. In deriving her scale, Espinosa defined research experiences and college GPA as the performance component, academic self-concept and measures of problem solving skills as the competence component, and measures of meaningful faculty interaction as the recognition component. Using Espinosa’s quantitatively derived method as a guide, a similar pattern for determining a Science Identity index score was used for this study.
<table>
<thead>
<tr>
<th>Item</th>
<th>Racial Climate α = .829</th>
<th>Social Capital α = .729</th>
<th>Cultural Capital α = .728</th>
<th>Academic Belonging α = .722</th>
<th>Perseverance α = .659</th>
<th>Diversity Efforts</th>
<th>Communalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alienated on campus due to ethnicity</td>
<td>.889</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.779</td>
</tr>
<tr>
<td>Alienated in STEM classes due to ethnicity</td>
<td>.861</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.826</td>
</tr>
<tr>
<td>Teachers underestimate my ability due to racial discrimination</td>
<td>.743</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.605</td>
</tr>
<tr>
<td>Persevere despite Institutional discrimination</td>
<td>.631</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.617</td>
</tr>
<tr>
<td>Advisors/Mentors source of Academic encouragement</td>
<td></td>
<td>.793</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.728</td>
</tr>
<tr>
<td>Teachers source of Academic Encouragement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.711</td>
<td></td>
<td>.659</td>
</tr>
<tr>
<td>Relationships of mutual trust with teachers/advisors will help me finish college</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.593</td>
<td></td>
<td>.652</td>
</tr>
<tr>
<td>Classmates source of Academic encouragement</td>
<td>.477</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.529</td>
</tr>
<tr>
<td>Better prepared to handle setbacks than in high school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.454</td>
<td></td>
<td>.465</td>
</tr>
<tr>
<td>My academic preparation is providing me with knowledge/skills necessary for a successful STEM career</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.709</td>
<td>.413</td>
<td>.682</td>
</tr>
<tr>
<td>My college’s career advice provides me with adequate knowledge/ preparation for job/grad school success</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.709</td>
<td></td>
<td>.650</td>
</tr>
<tr>
<td>My college is preparing me well for my chosen career path</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.707</td>
<td></td>
<td>.391</td>
</tr>
<tr>
<td>I have the skills to get administrative questions answered (fin aid forms, internship apps, etc.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.570</td>
<td></td>
<td>.525</td>
</tr>
<tr>
<td>If falling behind in a class, I know exactly where to go to get help.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.437</td>
<td></td>
<td>.629</td>
</tr>
<tr>
<td>Felt sense of belonging in academic community in first year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.797</td>
<td></td>
<td>.551</td>
</tr>
<tr>
<td>Felt sense of belonging in academic community in sophomore (2nd) year</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.770</td>
<td></td>
<td>.576</td>
</tr>
<tr>
<td>Felt sense of belonging in academic community in junior (3rd) year</td>
<td>.438</td>
<td>.505</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.699</td>
</tr>
<tr>
<td>Seriously thought about quitting college</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.817</td>
<td></td>
<td>.758</td>
</tr>
<tr>
<td>Seriously thought about quitting STEM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.763</td>
<td></td>
<td>.487</td>
</tr>
<tr>
<td>Campus takes diversity issues seriously and has effective programs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.790</td>
<td>.650</td>
</tr>
</tbody>
</table>

Note: factor loadings <.30 were suppressed
In order to determine how each of these particular variables correlated to one another in this study, a correlation matrix of research experiences, college GPA, mathematics self-concept, problem-solving self-concept, faculty recognition in STEM and peer recognition in STEM was constructed (see Table 5). Since Carlone and Johnson’s (2007) model pertains specifically to women of colour, only responses from URM female STEM students were used in this explicit analysis.

As each of the domains of performance, competence and recognition are seen as overlapping spheres of influence in the formation of Science Identity (Carlone & Johnson, 2007), items from one domain that were not significantly correlated to items in the other two domains were removed from inclusion in the construction of a Science Identity index score. Therefore, GPA was used to determine the performance component, mathematics self-concept was used for the competence component and the mean of the two items related to recognition as a talented person in science was used for the recognition component for the composite index score for Science Identity for URM female STEM students in this study.

Table 5

*Correlation Matrix of Items Related to Science Identity for URM female STEM students (N=94)*

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Research Experiences</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. GPA</td>
<td>.041</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Competence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Math Self-Concept</td>
<td>.093</td>
<td>.391**</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. ProbSolv Self-Concept</td>
<td>.175</td>
<td>.052</td>
<td>.238*</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Recognition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Teachers recognise me as talented in science</td>
<td>.312**</td>
<td>.546**</td>
<td>.236*</td>
<td>.134</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6. Classmates recognize me as talented in science</td>
<td>.163</td>
<td>.537**</td>
<td>.311**</td>
<td>.153</td>
<td>.733**</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: (2-tailed); ** p < .01; * p < .05
GPA, mathematics self-concept and recognition by others as a talented person in science were measured on different numeric scales. Therefore, a way to standardize these measures was needed. To accomplish this, a z-score was first calculated for each item which allowed a standard measure to be constructed. Then the z-scores were summed for a composite Science Identity index with equal weighting given for the three domains (performance, competence, recognition). A visual inspection of the histogram and normal Q-Q plots showed that this newly generated Science Identity variable was normally distributed for URM female STEM students (n=94), with a skewness of -0.319 (SE=0.254) and a kurtosis of 0.452 (SE=0.503) (Cramer & Howitt, 2004). The Shapiro-Wilk test of normality produced a significance level of 0.176. This statistic is usually used when sample sizes are less than 100. Since this significance level is greater the 0.05, normality is assumed.

**Quantitative Variables**

After specific factors for Campus Racial Climate, Acquired Cultural Capital, Acquired Social Capital, and Early STEM Academic Belonging were constructed through factor analysis, and an index score for Science Identity for URM women in STEM was determined, a full description of the quantitative variables used in this study was generated (see Table 6).
Table 6
Quantitative Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic</strong></td>
<td></td>
</tr>
<tr>
<td>Mother Highest Level of Education</td>
<td>1: Less than High School diploma; 2: High School diploma; 3: Some college/no degree; 4: Associate’s (2-year) degree; 5: Bachelor’s degree; 6: Graduate degree</td>
</tr>
<tr>
<td>Father Highest Level of Education</td>
<td>1: Less than High School diploma; 2: High School diploma; 3: Some college/no degree; 4: Associate’s (2-year) degree; 5: Bachelor’s degree; 6: Graduate degree</td>
</tr>
<tr>
<td>First-Generation College Student</td>
<td>(neither parent received Bachelor’s degree)</td>
</tr>
<tr>
<td>Mother’s Occupation</td>
<td>1: STEM related; 2: non-STEM related</td>
</tr>
<tr>
<td>Father’s Occupation</td>
<td>1: STEM related; 2: non-STEM related</td>
</tr>
<tr>
<td>Family Income</td>
<td>1: less than 60K; 2: 60-80K; 3: 80-100K; 4: 100-150K; 5: greater than 150K; 6: don’t know; (19% of values missing; imputed based on parents’ education and ethnicity)</td>
</tr>
</tbody>
</table>

**Pre-College Level Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School Location</td>
<td>1: Urban; 2: Suburban; 3: Rural</td>
</tr>
<tr>
<td>High School Graduating Class Size</td>
<td>1: Small (1-150); 2: Medium (151-300); 3: Large (&gt; 300)</td>
</tr>
<tr>
<td>High School Type</td>
<td>1: Public; 2: Private; 3: Catholic; 4: All-Girls</td>
</tr>
<tr>
<td>Percentage of high school Class that enrolled in college/university</td>
<td>1: 90-100%; 2: 75-90%; 3: 50-75%; 4: 25-50%; 5: less than 25%; 6: don’t know</td>
</tr>
<tr>
<td>Minority composition of HS</td>
<td>1: more than ½; 2: about 1/3; 3: about ¼; 4: less than ¼; 5: don’t know</td>
</tr>
<tr>
<td>Educational expectation for high school student body</td>
<td>1: just finish high school; 2: some college; 3: finish college; 4: pursue advanced degrees</td>
</tr>
<tr>
<td>Student’s High School Peer Group academic influences:</td>
<td>Yes=1/ No=0; Sum = 0-5 Get good grades; Study; Finish HS; Continue education past HS; Complete college degree</td>
</tr>
<tr>
<td>Student’s high school peer group social influences:</td>
<td>Yes=1/ No = 0; Sum = 0-3 Play sport; Make friends; Enjoy life/have fun</td>
</tr>
<tr>
<td>Family encouraged college attendance:</td>
<td>Yes= 1/ No=0; Sum = 0-3 Parents; Siblings; Other family</td>
</tr>
<tr>
<td>Variable</td>
<td>Definition</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
</tr>
<tr>
<td>School personnel encouraged college attendance:</td>
<td>Yes=1/ No=0; Sum = 0-3 Teacher; Counsellor; Other</td>
</tr>
<tr>
<td>College application help provided by HS or support program:</td>
<td>Yes = 1/ No= 0; Sum = 0-6 College Application; SAT/ACT prep; Essays; Fin Aid Apps; College Visits; Final College Decision</td>
</tr>
<tr>
<td>STEM classes taken in H.S.</td>
<td>Yes=1/ No= 0; Sum =0-15 (IB HL classes = AP Level) AP Calculus; AP Biology; AP Chemistry; AP Physics; AP Computer Science; AP Environmental Science; AP Statistics; Calculus; PreCalculus; Biology; Chemistry; Physics; Computer Science; Earth Science; Statistics</td>
</tr>
<tr>
<td>STEM related enrichment program prior to college</td>
<td>Yes = 1/ No = 0</td>
</tr>
<tr>
<td>High School GPA</td>
<td>5: (A/A-); 4: (B+/A-); 3: (B/B+); 2: (B/B-); 1: (C+/B-)</td>
</tr>
<tr>
<td>Parental involvement</td>
<td>Yes = 1/ No= 0; Sum = 0-6 Attended Parent/Teacher nights; Volunteered at school; Attended PTA meeting; Organised tutoring; Attended school events; Helped with homework</td>
</tr>
<tr>
<td>Mother’s educational expectations</td>
<td>1=Yes/ 0=No Mother expects Bachelor’s degree; Mother expects Graduate degree</td>
</tr>
<tr>
<td>Father’s educational expectations</td>
<td>1=Yes/ 0=No Father expects Bachelor’s degree; Father expects Graduate degree</td>
</tr>
</tbody>
</table>

**College Level Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extracurricular Involvement</td>
<td>Yes= 1/ No= 0; Sum = 0-9 Attended Diversity Clubs/ Events; Sought Academic Help; Research Experience; Peer Tutoring; Academic or Professional Club Membership; Internship Experience; Volunteered; Professional Mentoring</td>
</tr>
<tr>
<td>Parents source of academic encouragement</td>
<td>Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
</tr>
<tr>
<td>STEM competitiveness</td>
<td>Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
</tr>
<tr>
<td>College’s diversity efforts and effective diversity programs</td>
<td>Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
</tr>
<tr>
<td>Seriously considered quitting college</td>
<td>Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
</tr>
<tr>
<td>Seriously considered leaving STEM</td>
<td>Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
</tr>
<tr>
<td>Racial Climate Factor</td>
<td>$\alpha = 0.829$ (1=Positive/ 5= Negative; average of composite items) Item Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
</tr>
</tbody>
</table>

78
Table 6 (Cont’d)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquired Social Capital Factor</td>
<td>α = 0.729 (1=Low/ 5= High; average of composite items)</td>
</tr>
<tr>
<td>1. Advisor/Mentor source of academic encouragement</td>
<td></td>
</tr>
<tr>
<td>2. Teachers source of academic encouragement</td>
<td></td>
</tr>
<tr>
<td>3. Formed relationships of trust to help me graduate</td>
<td></td>
</tr>
<tr>
<td>4. Classmates source of academic encouragement</td>
<td></td>
</tr>
<tr>
<td>5. Better prepared to handle setbacks</td>
<td>Item Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
</tr>
<tr>
<td>Acquired Cultural Capital Factor</td>
<td>α = 0.728 (1=Low/ 5= High; average of composite items)</td>
</tr>
<tr>
<td>1. Received academic prep for successful STEM career</td>
<td></td>
</tr>
<tr>
<td>2. Received career advice for successful STEM path</td>
<td></td>
</tr>
<tr>
<td>3. College preparing me well for chosen career path</td>
<td></td>
</tr>
<tr>
<td>4. Possess skills to get admin questions answered</td>
<td></td>
</tr>
<tr>
<td>5. Know where to go if need help or falling behind</td>
<td></td>
</tr>
<tr>
<td>Early STEM Academic Belonging Factor</td>
<td>α = 0.722 (1=Low/ 5= High; average of composite items)</td>
</tr>
<tr>
<td>1. Felt sense of academic belonging in first year</td>
<td></td>
</tr>
<tr>
<td>2. Felt sense of academic belonging in second year</td>
<td></td>
</tr>
<tr>
<td>Overall Multi-Ethnic Identity Measure (MEIM)</td>
<td>α = 0.898 (1=Low/ 5= High; average of composite items)</td>
</tr>
<tr>
<td>Item Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
<td></td>
</tr>
<tr>
<td>Ethnic Identity Exploration Subscale (MEIM-EI)</td>
<td>α = 0.775 (1=Low/ 5= High; average of composite items)</td>
</tr>
<tr>
<td>Item Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
<td></td>
</tr>
<tr>
<td>Ethnic Identity Commitment Subscale (MEIM-EC)</td>
<td>α = 0.868 (1=Low/ 5= High; average of composite items)</td>
</tr>
<tr>
<td>Item Scale 1-5: 1= Strongly Disagree/ 5= Strongly Agree</td>
<td></td>
</tr>
<tr>
<td>Science Identity Scale for URM women in STEM</td>
<td>Composite z-score of GPA, Math self-concept and teachers/ classmates recognition of student’s potential in STEM (range: -6.33 to 5.48 )</td>
</tr>
<tr>
<td>Mathematics Self-Concept Factor</td>
<td>α = 0.900 (1=Low/ 8= High; average of composite items)</td>
</tr>
<tr>
<td>Item Scale 1-8; 1=Definitely False/ 8=Definitely True</td>
<td></td>
</tr>
<tr>
<td>Problem-Solving Self-Concept Factor</td>
<td>α = 0.778 (1=Low/ 8= High; average of composite items)</td>
</tr>
<tr>
<td>Item Scale 1-8; 1=Definitely False/ 8=Definitely True</td>
<td></td>
</tr>
</tbody>
</table>

Quantitative Data Analysis

Descriptive statistics pertaining to the participant’s ethnicity, characteristics of secondary school attended, parents’ education, parents’ occupation and family income were generated. Quantitative data were analysed and inferential statistics were
generated in direct relationship to the guiding research questions outlined in this thesis. Supporting analysis of qualitative data will be described later in this chapter.

Significance testing was set at $p < .05$. In the case of post-hoc analyses, a Bonferroni correction was applied to reduce the probability of a Type I error (A. Field, 2009). This next section highlights each guiding research question and the analyses undertaken to explore each question.

Q1: What aspects of pre-college background and inherited cultural and social capital provide the competencies necessary for persistence for women in STEM at a liberal arts college?

For women who have persisted into their third year of STEM study, demographic/pre-college variables of mother’s educational level, father’s educational level, family income, high school quality indicators, peer group academic influences, persons that encouraged college attendance, level of assistance with college applications, level of parental involvement during high school, parental aspirations, number of high school STEM classes undertaken and high school GPA were analysed for the two independent samples of URM women and non-URM (White/Asian women) through a Mann-Whitney U test. This test is similar to a $t$-test and is appropriate for ordinal level data. The Mann-Whitney U test allows for the comparison of two independent samples in which the populations do not have to be normally distributed, a requirement of the $t$-test. The null hypothesis is that the mean ranks of the two population groups are equal. While this nonparametric test is considered distribution free, the shapes of the distributions should be similar. Histograms for each of these variables were visually assessed and each pair of distributions (URM and non-URM) displayed similar shapes (Nachar, 2008).
A chi-square test of independence was performed to assess the relationship between ethnicity and the pre-college variables of first-generation college status, mother in a STEM occupation, father in a STEM occupation, and attendance at a STEM enrichment program, as well as the individual sources of assistance and encouragement offered to students in the college application and decision process. A chi-square statistic was calculated to determine if these samples reflect independence in the groups of URM and non-URM female STEM students.

Q2: In what ways do college experiences, college support structures, perceptions of campus environments, and resourceful campus relationships differ for URM and non-URM women who persist in STEM and how do these measures differ for URM women at different types of colleges?

To explore the quantitative response to the first part of the question, a Mann-Whitney U test was undertaken for each of the variables representative of College Experiences, College Support Structures, Perception of Campus Environment and Resourceful Campus Relationships, and comparisons were made between the two independent groups of URM and non-URM female STEM students. The data requirements for this nonparametric test were met by each of the variables for each of the student groups. In carrying out the test, College Experiences were represented by the variables of seriously considered quitting college, seriously considered quitting STEM, STEM competitiveness, GPA and total number of extracurricular activities. College Support Structures were represented by the factor of Acquired Cultural Capital, the individual items that determined that factor, and the variable of adequate financial aid. Perceptions of Campus Environments were represented by the factors of Racial Climate, Early STEM Academic Belonging, the individual items that determined those factors, and the variable of campus’ diversity efforts/programs. Resourceful Campus Relationships were represented by the Acquired Social Capital factor as well as the
individual items that determined that factor. Additionally, a chi-square statistic for each of the individual extracurricular activities was generated to determine if there were any significant findings within the types of activities in which each either URM or non-URM female STEM students participated.

Then, in order to test if these measures for URM female STEM students differed significantly based on the type of college attended (coeducational, women’s or HBCU), a Kruskal-Wallace test was applied. This test extends the Mann-Whitney U test for more than two groups. This one-way analysis of variance test is similar to an ANOVA test but assesses mean ranks, instead of means. ANOVA tests generally require that data are either interval or ratio. Since Likert-type data is considered ordinal in nature, the Kruskal-Wallace test was chosen as the more appropriate test for comparing more than two groups. Similar to a Mann-Whitney U test, the Kruskal-Wallace test also requires that the shape of the distributions of data be similar for each comparison group. After visually assessing the histograms, this requirement was met except for the data items relating to Racial Climate for the three sub-samples of URM female STEM students at the three different college types. Therefore, a Fisher’s exact test was applied to that subset of data. Post-hoc analysis was undertaken to determine the rankings between the different groups (college type) in which the null hypothesis was rejected. A Bonferroni correction was applied to reduce the probability of a Type I error. Additionally, a chi-square statistic for each of the individual extracurricular activities was generated to determine if there were any significant findings between the different colleges for the types of activities in which URM female STEM students participated.

Q3: Do campus environments and ethnic identity affect the acquisition of cultural capital for URM women who persist in STEM and do prior levels of inherited cultural capital affect measures of capital acquired during the college years?
This question probes two distinct concepts related to the acquisition of cultural capital for URM female STEM students during college. The first part of this question looks at the college environment or field in which the capital is situated, as well as specific measures of ethnic identity and how those contexts may impact the measure of cultural capital acquired during college. The ability to assess a measure of ethnic identity for URM female STEM students who persist, and its’ impact on the cultural capital assumed necessary for persistence, were critical in testing Tierney’s (1999) concept of Cultural Integrity which is integral to this study. The second part of the question considers the potential connection between inherited cultural capital and the cultural capital acquired or “learned” during the college experience.

To explore the first part of the question, a correlation matrix of the dependent variable of Acquired Cultural Capital, and the predictor variables of Racial Climate, campus’s diversity efforts/programs, Early STEM Academic Belonging, MEIM, MEIM-EI, MEIM-EC was constructed. To explore the second part of the question, another correlation matrix was constructed with the dependent variable of Acquired Cultural Capital and the independent variables that represented inherited cultural capital. Consistent with many other studies, operationalised variables for inherited cultural capital included mother’s educational level, father’s educational level, mother’s occupation, father’s occupation and family income (Winkle-Wagner, 2010). For this analysis, and based on work by Perna (2000) and Wells (2008), the variables pertaining to inherited cultural capital were extended to also include educational expectations of high school, sources of help with the college application process, participation in a STEM enrichment program in high school, the academic influence of high school peers, encouragement to attend college by family, encouragement to attend college by other adults (teachers, counsellors), and parental involvement during high school.
The predictor variables for both bivariate analyses that produced a statistically significant correlation \((p < .05)\) with the dependent variable of Acquired Cultural Capital were then included in a multiple linear regression analysis. The bivariate correlations produced a modest set of significantly correlated variables and at a minimum it is recommended that there are at least five times as many predictor variables as cases (Coakes, 2013). With more than 90 URM students represented in this particular sample, this condition was amply satisfied.

Generally, predictor variables for a multiple linear regression analysis are either numerical (continuous) or nominal. With the exception of campus’ diversity efforts/programs, each of the regression predictor variables met that requirement. However, in certain circumstances, predictor variables that consist of Likert-type response data, which is typically considered ordinal data, may be used in regression analyses. An inspection of a P-P plot for the campus’ diversity efforts/programs showed a linear relationship between this predictor variable and the dependent variable of Acquired Cultural Capital and was thus included in the regression analysis (Grace-Martin, 2008).

Q4: Do campus environments and measures of acquired cultural and social capital affect the formation of science identity for URM women who persist in STEM at a liberal arts college?

This question sought to discover if campus environments, campus experiences, and acquired cultural and social capital were predictive in the formation of Science Identity for URM women who have persisted in STEM. In order to explore these relationships, a correlation matrix with the dependent variable of Science Identity, and the predictor variables of Racial Climate, campus’ diversity efforts/programs, Early STEM Academic Belonging, Acquired Cultural Capital and Acquired Social Capital
was constructed. The predictor variables that yielded a significant correlation \( (p < .05) \) to the dependent variable of Science Identity were then included as independent variables in a multiple linear regression analysis.

For each of the multiple regression analyses undertaken in this thesis, the data were checked to assure that assumed conditions for data used in a regression analysis were met. The data were also checked for outliers by evaluating the standardised residual values. Through evaluating the VIF and tolerance values, the data was also tested to assure that the assumptions of collinearity were met. A Durbin-Watson value was calculated for each regression analysis to determine if the data met the assumption of independent errors. The data were also tested to see if the assumption of non-zero variance was met. The normality of residuals was checked using a P-P plot of standardized residuals.

Q5: In what ways do parents, external mentors and other non-campus resourceful relationships influence URM women’s continued persistence in STEM?

In order to explore this question, identification of those who were considered external mentors and what were considered as resourceful relationships outside of the campus experience were defined and clarified. A correlation matrix was constructed to investigate these relationships further. Included in this matrix were the variables of: mother’s education, mother’s occupation, father’s education, father’s occupation, first-generation status, family income, whether or not a student had a professional mentor, sources of academic encouragement from parents, relationships of trust to help finish college, mother’s educational expectations and father’s educational expectations. Significant bivariate correlations \( (p < .05) \) were noted. The results from this correlation analysis served as a springboard for a more comprehensive and thoughtful analysis of this question that was garnered through the analysis of the qualitative interview data.
Where appropriate, chi-square tests of independence and Mann-Whitney U tests were run.

**Effect Size**

Effect Size is often seen as a way to measure the magnitude of the size of difference between groups and allows for a more practical interpretation of significant findings (A. Field, 2009). For each of the statistical tests conducted in this study, an effect size was determined. For regression equations, observed standardized regression coefficients ($\beta$) were used as a way to easily interpret effect size (Nieminen, Lehtiniemi, Vähäkangas, Huusko & Rautio, 2013). In addition, R squared ($R^2$) was also calculated to determine the proportion of the variability in the dependent variable that was explained by the set of predictor variables (Fritz, Morris & Richler, 2012). For Chi-square statistics, an effect size was determined though calculating a value for Phi ($\phi$) for 2 x 2 contingency tables and a value for Cramer’s V for contingency tables where either the row or column exceeded two. For the Mann-Whitney U test, effect size was determined though the calculation of $r$ ($r=Z/\sqrt{N}$) (A. Field, 2009). Cohen’s (1992) suggested range of effect sizes ($r=.10$ small; $r=.30$ medium; $r=.50$ large) were applied with the Chi-square and Mann-Whitney U tests. For the Kruskal-Wallis test, an eta squared ($\eta^2$) value was calculated (chi-square/(n-1)) in order to determine effect size for between group comparisons. Effect sizes using eta squared ($\eta^2$) as a measure were determined as small (.01), medium (.06) and large (.14) (Green & Salkind, 2008). The interpretation of effect size, relative to each statistically significant result, is discussed in the next chapter.
Qualitative Data Analysis

Thirty face-to-face interviews with URM female students in STEM were completed and analysed for this study. The women who were interviewed ranged the educational span of having just completed their second year of STEM study to preparing to graduate and enter the workforce or post-graduate study. Interviews took place on campus at each host college (women’s college, coeducational college or HBCU). Interview participants came from four of the five colleges participating in this study. Participants from one of the two coeducational colleges in this study did not take part in the interviews. All 30 interviews were digitally recorded. Interview lengths ranged from 23 to 64 minutes, with the mean interview time of 41 minutes. To ensure confidentiality, interview participants were assigned a pseudonym.

An outside agency performed the verbatim transcriptions for all digitally recorded interviews. Once completed, the verbatim transcripts were then read twice by a professional agency to assure transcription accuracy. Once this process was completed, interview transcripts were read by this researcher in tandem with the audio recording to further assure precise verbatim accuracy. In order to enhance readability, false starts, excessive meaningless words (eg. like) and multiple repetitive filler words (eg. um, ah) were dropped as well as minor adjustments made to grammar. Once this process was completed, the interview transcripts were then uploaded into NVivo v.10 software for further analysis.

Interview transcripts were read multiple times as the beginning steps of analysis. A narrative approach was first undertaken as a means to understand the unique story of each interviewee. Narrative analysis allows the researcher to explore the “cultural and social patterns through the lens of individual experiences” (Patton, 2002, p. 478). In order to create a narrative for each interview participant, common themes from the
interviewee’s responses were grouped together following a thematic strategy (Riessman, 2008). As part of the interview process, students were given the freedom during the semi-structured interview process to digress from the posed questions, and to choose and develop their own path of response. At times, interviewees would come back to a topic explored in a prior segment of the interview after having more time to reflect upon an earlier line of thinking, or even explore a line of thought not explicitly outlined in the interview questions. In this initial qualitative analysis, focus was given to the common themes that emerged within these interview narratives through an open coding process.

Since this study began with certain propositions based on the conceptual model devised for this study, analytic induction was then the next method of analysis as focus was given to various texts that related directly to the posed research questions and conceptual framework. The analysis assumed a deductive approach as data was then examined by applying the theoretical frameworks of this study. A classification scheme based on the emergent themes, the research questions and the theoretical frameworks was devised. Content analysis was undertaken, as data was coded and labelled with these primary themes of pre-college background, career aspirations, the role of parents, family and other models, relationships with mentors and faculty, the overall college environment, school culture, STEM classroom culture, faculty interaction, academic advising, academic clubs, social/diversity clubs, internship and research experiences, social networks, perceptions of racial discrimination, ethnic/cultural background and financial aid. After this phase of the analysis was complete, then a fresh look using inductive analysis was given to the data with the goal of finding those “undiscovered patterns and emergent understandings” (Patton, 2002, p. 454). This process overall produced close to 100 unique themes and codes.
Part of this analytic process was to deal effectively with seeking those “recurring regularities” that converged towards revealing important patterns in the data. Focus was maintained towards assuring that the coding process allowed meaningful categorisation of the data, as well as clarifying that the differences between the categories, themes and codes were precise and clear, thereby meeting the criteria of “internal homogeneity and external heterogeneity” (Patton, 2002, pg. 465). Logical Analysis was the final method used for analysing and interpreting the interview data. A matrix was created by listing all the interview codes in a vertical column and all the interview participants in a horizontal row. The interview data was then quantified and then cross-classified by creating categories of crossing one dimension of the data with another, further facilitating the recognition of patterns and relationships amongst the interviewees’ responses that were not easily recognizable through inductive analysis. Additionally, this method assisted in understanding the deeper connections between those experiences deemed either common or unique between students at similar or at different colleges, or by students from similar cultural backgrounds.

Validity and Reliability

Using a mixed-methods convergent design, both quantitative and qualitative data were collected for this study. The interview protocol and questionnaire used in this study were designed in tandem and were administered within the same time frame on each of the campuses. This next section summarises the processes that were undertaken to ensure validity and reliability of research results.

Quantitative data. The questionnaire devised for this study was divided into four sections. Within the questionnaire, the prompts from three of the four sections (I, III, IV) came directly from previously published instruments in the literature which have been found to be valid and reliable in prior research. In Section I of the
questionnaire, prompts 1-28 are a combination of descriptive prompts, and cultural/social capital prompts used in Perna’s (2000) study, and in turn replicated in Wells’ (2008) research. These particular prompts offered a means to operationalise particular attributes of students’ cultural and social capital prior to college matriculation, concepts explored in this study. “Theoretical concepts must be operationally defined to provide valid and reliable measures” (Abowitz & Toole, 2010, p. 110). In Section III, prompts 55-67 were taken directly from the Multi-Ethnic Identity Measure (MEIM) scale (R. Roberts et al., 1999) and in Section IV, prompts 68-87 were taken directly from the Self-Descriptive Questionnaire (SDQ III) (Marsh & O’Neill, 1984; Marsh, 1992). These scales have been used extensively in the literature and validated in prior research (Ponterotto et al., 2003; Worrell, 2000; Byrne, 1988). In this study, coefficients of reliability were determined for each of these numerical scales through measuring a Cronbach’s alpha for each scale and subscale. As all coefficients were greater than .70, these scales were determined to be reliable (Nunnally, 1978; George & Mallery, 2003). In Section II, prompts 29-54 were original, and constructed specifically for this study. Each prompt related directly to one of the five guiding research questions posed in this study. Construct validity is offered through a process of matching each prompt to a related concept from the guiding research questions. “Theoretical concepts must be explicitly defined before they can be measured” (Abowitz & Toole, 2010, p. 110). Construct validity was further enhanced through the statistical process of factor analysis where originally constructed prompts were matched to particular concepts being explored in this study (P. Roberts et al., 2006; Abowitz & Toole, 2010). The Cronbach’s alpha for each factor constructed through this analysis was greater than .70 displaying the reliability of these newly developed scales.
Qualitative data. In exploring the data gathered from the interviews, descriptive validity was gained through the use of purposive sampling strategies (Patton, 2002). The selection of thirty interview respondents who met key criteria allowed for saturation of the data to be met. Verbatim transcriptions of the interview data also enhanced the descriptive validity and reliability of results (Roberts, Priest & Traynor, 2006). Each interview transcript was checked for verbatim accuracy by two professional transcribers and then by this researcher. In addition to the verbatim transcription of text, field notes that described emotional postures and affective qualities portrayed during the interviews added to the interpretive validity of the results. The qualitative data were analysed using multiple methods. Employing this within-method form of triangulation also increases the interpretive validity of the results through “cross-case analysis and comparisons across data from different groups of participants” (P. Roberts et al., 2006, p. 44). Through careful data analysis, precaution was taken to offer an accurate interpretation of the qualitative data, matching it to the theoretical frameworks and guiding research questions, as well as noting findings that were unexpected or unanticipated (Maxwell, 1992; Miles & Huberman, 1994). The use of NVivo v.10 software also enhanced reliability and validity through providing a systematic means of analysing the qualitative data (Siccama & Penna, 2008).

Triangulation. Utilising both quantitative and qualitative methods offered a means to further validate findings through verification from multiple data sources. As different methods employed in this study converged towards similar, yet complimentary results, triangulation of the quantitative and qualitative components of this study adds greater validity to the research results and strengthens the conclusions that may be drawn from this study (Jick, 1979; Patton, 2002). However, the end goal of triangulation
is not merely validation of research results, but a “deepening and widening one's understanding” of those results (Yeasmin & Rahman, 2012, p. 154).

**Ethical Considerations**

Ethics approval was granted by each of the participating institutions in this research project. As part of the ethics approval process, each college required that researchers complete a human subjects research course offered through the Collaborative Institutional Training Initiative (CITI). A completion certificate from this researcher was submitted in the documentation package to the respective IRBs.

The quantitative data generated for this study was captured electronically. Surveys were delivered via student email and then completed online. The purposes of this study were clearly outlined in the participation email invitation. More detailed information was outlined in the preface to the survey as well as noting that students’ participation was anonymous (see Appendix C). For the survey, unsigned consent was obtained from the participants through “clicking” a consent box on the online survey. Survey responses were collected over secured, encrypted SSL/TLS connections. IP addresses were not collected so there was no way to link students or their identities to their responses; anonymity of survey respondents was thus assured. All electronic data sets compiled based on survey responses, as well as all digitally recorded interviews, continue to be stored in a secure, password protected Google Cloud account which provides server side data encryption.

Risks associated with participating in this study were low. Topics of social background, ethnic background and perceptions of discrimination could have potentially made some respondents uncomfortable. Students had control over their survey responses as they could skip questions or end the survey at any time. Students who
participated in an interview were told of the interview topics before the start of the interview and were informed that they could stop the interview at any time. After reviewing the Participation Information Statement (see Appendix D), interview participants were required to review and sign an Informed Consent form before beginning the interview (see Appendix E). In order to maintain confidentiality, interview participants were assigned a pseudonym (see Table 3). Participating higher education institutions, and associated campus programs, were also provided with pseudonyms.

**Limitations and Delimitations**

Limitations are often perceived as weaknesses in a study that may have been unavoidable from the researcher’s point of view and over which the researcher may have had little control (Pajares, 2007). This study presented with several limitations. First, the self-reporting nature of surveys can in and of itself be considered a limitation. For example, students were asked to self-report their grade point averages (GPA), both for secondary school and for college. Students may have felt pressure to inflate this measure of academic achievement. However recent studies assessing the validity of self-reported grades found that students’ actual grade point averages were not statistically different than the grades that students self-reported (Cassidy, 2001; Massey, Charles, Lundy & Fischer, 2003).

Second, in order to assess a measure of socioeconomic status (SES) in this study, students were asked to self-report their family income. For students who were recipients of financial aid, they would have had access to what their parents report as their family income as both students and parents need to apply their signatures to the mandated federal financial aid form (FAFSA) in which reporting family income and
submitting federal income tax returns are requirements. Students may have felt internal pressure to report what they deemed as an acceptable level of family income rather than actual income. Unlike students who received financial aid from their institution, students who did not apply for financial aid may not have had first-hand knowledge of their families’ income and may have just given a best-guessed estimate, which may or may not have been completely accurate. Additionally, 19% of students indicated that they “didn’t know” their family income or just left the prompt blank. While these missing values were imputed based on parents’ educational levels and ethnicity, caution should be taken when interpreting results that consider family socioeconomic status (SES) as the missing values for this variable were extremely close to the 20% threshold for imputation.

Another potential limitation of this study related to the financial aid assistance offered by the different types of colleges that participated in this study. The two women’s and two coeducational colleges in this study guaranteed to meet between 95-100% of a student’s financial need to attend their institution. For many students, this most likely relieved a great proportion of the financial burden of college attendance, and in some ways allowed for financial need to be controlled as a variable in persistence. However, the HBCU in this study only guaranteed to meet 85% of a student’s financial need and a lack of financial funds may have affected persistence. Students at that college may have also had to assume a greater financial burden to persist, a burden not present for the students at the women’s or coeducational colleges.

A delimitation of the study pertains to the sample size breakdown between student groups (URM and non-URM) as well as between students who attended a women’s college, a coeducational college or an HBCU. One way to handle the different sample sizes between URM and non-URM women would have been to only randomly
sample survey responses in the non-URM group so that the sample sizes between groups would have been equal. However, in doing this valuable data could potentially be lost. Additionally, it was believed that the unequal sample sizes better reflected the actual demographic distribution of the different ethnic groups found within the student enrolments at these colleges. The statistical tests applied to these groups allowed for unequal sample sizes. Also, due to the inability to recruit more than one HBCU to participate in this study, the representative distribution of URM female STEM students between the three types of higher education institutions is also not equal. When statistically comparing the samples from these three types of institutions, a Kruskal-Wallis test was applied as this test does not require equal sample sizes for the comparison groups. Yet, caution should be taken when interpreting results. When drawing comparisons between URM female STEM students based on type of college attended, the sample size in each sub-group is small. Although sample size requirements for each of the statistical tests were met, interpreting results should be limited to the participating students and not generalised to all URM female STEM students who attend these types of colleges.

The focus of this study centred upon the experiences of underrepresented racial minority women who have persisted beyond two years of university study in STEM. Comparisons were drawn between URM and non-URM female STEM students who had completed a minimum of four semesters of their STEM degrees. Within this defined sample, additional comparisons were made between URM female STEM students who had attended different types of colleges (coeducational, women’s, HBCU). As this study focused on students who were exemplars of persistence, data was not gathered from students who had left their STEM degree programs. Therefore, in this study there are no comparisons drawn between persisters and leavers.
Even though 447 female STEM students of all racial backgrounds were surveyed for this study, only URM female STEM students (n=30) were interviewed. Although these interviews allowed for a greater depth of insight and discussion into the experiences of URM female STEM students, a comparison group of White/Asian women were not similarly interviewed. Therefore, when reporting statistical comparisons between URM women and non-URM women, the qualitative discussion that follows only explores the voices of the URM women who were the predominant focus of this study.

The next chapter discusses the institutional setting and research context for this study and offers a frame for the contextualization of the quantitative and qualitative data collected for this study within the particular landscapes of the participating institutions of higher education.
Chapter 4: Institutional Setting and Research Context

The overall purpose of this study is to gain a better understanding of how the organisational environment and social practices experienced at different types of liberal arts colleges affect the persistence of women of colour in STEM. Generally speaking, liberal arts colleges in the United States, with their concerted focus on undergraduate education, demonstrate more success in retaining STEM undergraduates than do larger research universities (Griffith, 2010; Espinosa, 2011). Additionally, graduates from liberal arts colleges are twice as likely to earn a PhD in science when compared to graduates from other baccalaureate granting institutions (Cech, 1999). In order to more fully grasp the specific contributions made by the women’s liberal arts colleges, coeducational liberal arts colleges and the HBCU in this study towards promoting persistence for minority women in STEM, it is important to explore the educational settings and the specific campus programs at each institution which create an array of experiences that may prove influential in the retention and affective behaviours of URM female STEM students.

In this chapter, the five higher education institutions that participated in this study will be described. Each of the institutions holds a basic Carnegie classification as a *baccalaureate college* which by definition indicates that in the most recent academic year, each institution awarded less than 30 doctoral degrees or 50 master’s degrees, and that more than 50% of the degrees awarded were bachelor’s degrees (Carnegie Classification of Institutions of Higher Education, 2016). Within each college, various programs and campus sub-environments that may influence persistence decisions for URM female STEM students are highlighted. The institutional setting, or field, provides a framework for linking quantitatively derived student outcomes that will be described in the next chapter with the contexts in which those outcomes were
determined. This “institutional dimension is as important as that of individuals” (Krarup & Munk, 2014, p. 22) as learning and outcome behaviours may be expressed as the interaction between the students and the social setting of a particular learning environment (Lewin, 1935). Table 7 presents various characteristics of the participating colleges. Colleges and non-national, local campus programs were assigned pseudonyms.

A detailed discussion on each of the institutions follows. The chapter concludes with a summary and comparison of programs offered at the participating institutions.

Table 7

**Characteristics of Participating Colleges**

<table>
<thead>
<tr>
<th></th>
<th>Women's Colleges</th>
<th>Coeducational Colleges</th>
<th>HBCU Colleges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Whitt</td>
<td>Woodard</td>
<td>Cahill</td>
</tr>
<tr>
<td>Undergraduate Enrolment (rounded to closest 100)</td>
<td>3000</td>
<td>2700</td>
<td>3600</td>
</tr>
<tr>
<td>First Year Admission Rate</td>
<td>43%</td>
<td>29%</td>
<td>29%</td>
</tr>
<tr>
<td>First to Second Year Retention Rate</td>
<td>94%</td>
<td>97%</td>
<td>94%</td>
</tr>
<tr>
<td>Student to Faculty Ratio *</td>
<td>9:1</td>
<td>8:1</td>
<td>9:1</td>
</tr>
<tr>
<td>Enrolment percentage by race/ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>48%</td>
<td>41%</td>
<td>78%</td>
</tr>
<tr>
<td>Asian</td>
<td>11%</td>
<td>22%</td>
<td>4%</td>
</tr>
<tr>
<td>Black</td>
<td>5%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>9%</td>
<td>10%</td>
<td>5%</td>
</tr>
<tr>
<td>Native American</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>2 or more races</td>
<td>5%</td>
<td>6%</td>
<td>3%</td>
</tr>
<tr>
<td>Non-U.S. resident</td>
<td>12%</td>
<td>11%</td>
<td>6%</td>
</tr>
<tr>
<td>Race Unknown</td>
<td>9%</td>
<td>5%</td>
<td>1%</td>
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<tr>
<td>Female Graduation Rate (6-year) by race/ethnicity</td>
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<td></td>
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<tr>
<td>White</td>
<td>84%</td>
<td>91%</td>
<td>93%</td>
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<tr>
<td>Asian</td>
<td>90%</td>
<td>89%</td>
<td>93%</td>
</tr>
<tr>
<td>Black</td>
<td>83%</td>
<td>84%</td>
<td>70%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>74%</td>
<td>92%</td>
<td>88%</td>
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<tr>
<td>2 or more races</td>
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<td>96%</td>
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<td>89%</td>
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<td>Race Unknown</td>
<td>90%</td>
<td>87%</td>
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<tr>
<td>Percent of bachelor’s degrees awarded in STEM</td>
<td>22%</td>
<td>21%</td>
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<tr>
<td>Percent of STEM degrees awarded to women</td>
<td>100%</td>
<td>100%</td>
<td>32%</td>
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<tr>
<td>Percent of Female Faculty *</td>
<td>55%</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>Percent of Minority Faculty *</td>
<td>17%</td>
<td>24%</td>
<td>15%</td>
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<tr>
<td>Percent of students receiving financial aid/scholarships</td>
<td>73%</td>
<td>68%</td>
<td>55%</td>
</tr>
<tr>
<td>Percent of financial need met b</td>
<td>100% *</td>
<td>100% *</td>
<td>95% *</td>
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</tbody>
</table>

*Native American population < 1%

Source: National Center for Educational Statistics (IPEDS Data Center: Academic Year 2012-2013); * Common Data Sets; b College Board
Whitt College

Whitt College is a women’s college located in a semi-rural area in the northeast section of the United States. Whitt College is also part of a consortium of colleges (both public and private) where students can cross register for classes. Founded nearly 150 years ago when higher education options for women were lacking, Whitt College still asserts that for some women, a women’s college is the best setting where women can develop their leadership and academic gifting. At Whitt, close to half of the faculty in the sciences are women, which offer natural role model relationships for women pursuing a STEM pathway. The academic community of students, staff and faculty at Whitt are highly engaged in ongoing discussions on topics relating to issues of diversity and equity in STEM. Below is a summary of several of the ongoing programs and initiatives at Whitt.

Community on Diversity in the Sciences. This committee of students, faculty and staff, develops, initiates and promotes programs at Whitt aimed at increasing diversity within STEM as well as stimulating educational discussions that seek to address social justice issues within STEM. Recognising that early success in STEM increases persistence for minority women, this committee works at developing new initiatives at both the individual and departmental level aimed at first-generation students and those from under-resourced backgrounds. Some of the specific efforts this committee supports are discussed below:

- Achievement Scholars Program. Scholars selected for this program are identified in the admissions process. Potential scholars are contacted before matriculation and invited into the program. Students who accept this offer are matched with a research professor with whom they will engage in research with during their first year. Upon starting college, scholars enrol in a seminar class which addresses
topics of study skills, time management and working with study groups. Students are also assigned a peer mentor who is often a returning Achievement scholar. Selected scholars also engage in community building and leadership opportunities. Achievement scholars present their research results in the Annual Achievement Scholars Research Symposium.

- **Early Research Program.** Students interested in pursuing a semester or year-long research project make application to this program. While this program may pave the way for future research opportunities, students participate in this first research experience in a volunteer capacity.

- **Honours Fellowship Program.** This program matches high potential students who have financial need with funding in order to pursue research.

- **STEM Peer Mentoring.** This program seeks to pair students (mentors and mentees) who are historically from underrepresented groups and who are interested in pursuing a STEM major. Mentors and mentees engage together in a variety of formal and informal activities focused on networking and support. Mentors receive training and ongoing support in this role.

- **Underrepresented Students in STEM.** This student led group is supported by the Community on Diversity in the Sciences and hosts the annual “Minorities in STEM” week and associated events. In past years, the week has featured talks from a variety of distinguished speakers.

- **Minority Association of PreHealth Students (MAPS).** MAPS is a supportive network of minority students who work together in their quest to become competitive candidates for medical or health related graduate school. MAPS is a national association and guides students toward volunteering and mentoring opportunities in the healthcare system.
**STEM Professions Weekly “Lunchbag” Series.** This popular event, which includes a free lunch, presents students with the opportunities to hear about a variety of STEM related discussion topics such as how to engage with faculty in research, the medical school admissions process and panel discussions on women in STEM. This series is hosted by the Office of STEM Advising.

**Internship Stipend Program.** Students are allowed to successfully apply only once for this stipend which allows students to engage in an unpaid internship in an area of student interest that in turn is funded by Whitt College. Students can use this stipend for internships both domestically and abroad.

**Summer Bridge Program for First-generation and Under-Served Students.** This residential program takes place soon before matriculation, before all students arrive on campus, and is aimed towards assisting entering first-generation and under-served minority students in their successful transition to higher education. Bridge program participants are allowed to experience the academic environment in an inviting setting and are encouraged to develop contact with faculty and staff.

**Summer Research Fellowships in the Sciences.** After successful application, students will engage in an independent 10-week research project with a STEM faculty member. While students are not offered housing, they do receive a generous stipend. At the conclusion of the program, participants prepare an abstract in typical journal format that will be published in university documents. Students also present their research project findings in a symposium format.

**Cultural Spaces.** This umbrella organisation hosts a variety of societies, clubs and student groups within a dedicated cultural space that exist to enrich the social and intellectual life of the college through embracing the diversity of the Whitt community. Some of the groups represented include the Black Students’ Alliance, the Latina
Students’ Cooperative, the Society of Indigenous Students and the African and Caribbean Students’ Association.

Whitt College displays its ongoing commitment to outreach efforts in STEM though its *summer program for girls in STEM*. This one month residential program aligns talented secondary school girls with the opportunity to engage in hands-on experiential learning in engineering. Participants in this program come from various regions of the United States. This program also offers scholarships for students from low-income backgrounds. Additionally, during the school year, the Society of Women Engineers (SWE) hosts an annual *Engineering is for Girls* day.

**Woodard College**

Located in a suburban area in the Northeast section of the United States, this women’s college is well-known for its intellectual rigour and fostering of future female leaders. Within ten years of graduation, 80% of Woodard College graduates who have majored in a science discipline will attend post-graduate or professional schools. More specifically, for those who studied biological-chemistry, 60% will enter post-graduate or professional school upon graduation. Women applying to post-graduate medical school are accepted at a rate of more than 50% above the national acceptance rate. Although Woodard College does not have an engineering program, students can major in engineering and take their specific engineering subjects at one of two partner engineering schools located in reasonable proximity to Woodard’s campus.

Woodard College is highly committed to the success of all its students. In addition, specific programs are also in place to address the unique needs of minority students, though a limited number of programs exist to address the more explicit needs of URM women in STEM. Several of the programs and initiatives are described below.
**Supplementary Instruction (SI).** Following the model established by the University of Missouri, and also implemented at another institution in this study (Hayden University), Supplemental Instruction at Woodard College offers all students additional academic group tutoring by students who have already successfully completed the STEM based course in which they assist. Participation in this program is extremely high at Woodard, and internal statistics have shown that students who participate in SI do better academically than students who do not. While participation in this program is optional for students, students who are struggling academically can be referred by faculty. At Woodard College, there is open communication between faculty, deans and support services so that students who are struggling academically do not “fall through the cracks”.

**Emerging STEM Talent.** This newer initiative at Woodard College exists to help URM women and those from under-resourced backgrounds develop the mathematical skills and confidence to pursue further STEM studies. Participation in this group is application based and selected participants meet bi-weekly with a professor to engage in small group problem solving activities with similar peers. The female STEM students in this study were not able to participate in this program as it was initiated after the women in this study would have completed their required calculus subjects in first year. However, just two years of data reveal that 60% of women who participated in this group earned higher course grades than women who did not participate. This program is run by a Latino mathematics professor.

**Residential Peer Tutors (RPT).** Second and third year students who are selected to be RPTs offer individual tutoring to other women who live in their residence hall. RPTs are required to have a strong GPA and available to work in this role at least 6-8
hours a week. Aside from offering tutoring and academic workshops, RPTs are encouraged to actively seek out students who would benefit from their assistance.

*First-generation Network.* This initiative is geared towards students for whom neither parent received a university or college education. Recognising the unique obstacles that first-generation students face, this program links first-generation students, of whom many are minority students, to each other for peer support and to alumnae for role model support.

*Science Research Opportunities.* Woodard College offers many opportunities for its students to participate in research during their undergraduate years. The academic environment is such that students can directly approach faculty to informally ask if they could work in their labs. Additionally there are also specific explicit programs in place that encourage student research.

- **Natural Science Student Research Initiative.** This application based program, geared specifically for second year students majoring in natural science, offers 14 students the opportunity to participate in paid research with faculty during the academic year.

- **Undergraduate Research Opportunities Program (UROP).** This program is offered in conjunction with another nearby research university and offers students the opportunity to work with science faculty at another university throughout the semester for either pay or course credit or in a volunteer capacity.

- **Summer Science Research Program.** This is a 9-week summer program in which students are funded to participate in an on-campus research project with a faculty member. In 2015, there were over 50 different research projects for which students could apply with approximately 150
student research positions on offer. Students who participate receive a stipend and housing allowance. In 2014, over 35% of students who participated in the summer research program were women from groups underrepresented in STEM. At the conclusion of the program, students are expected to present their work in a poster presentation.

- **Travel Funding.** A variety of grants are available to students in order to present their research at scientific conferences.

- **Science Outreach Program.** At Woodard College there are several on-campus and off-campus opportunities for students to work within the broader community promoting STEM learning for younger students. These outreach programs allow Woodard students to serve as role models with students who are traditionally under-served in STEM.

**PRISM Black Students’ House.** PRISM is a dedicated cultural space that offers a variety of social and academic networks for students of African descent. Students consider PRISM a “safe space” where they can gather and develop the social capital needed to succeed as women of colour in a PWI. PRISM is run by a full-time director who manages a variety of programs from chemistry tutoring with a professor of colour to mentoring with alumnae of African descent.

**Latina Student Association (LSA).** Similar to PRISM, this cultural association is multifaceted, has many initiatives and is run by a full-time director. LSA has published a “first-year” guide for incoming Latina students and offers both social and academic outlets for students. As Latina students can hail from a variety of national cultures, LSA offers students a variety of communities in which Latina students can participate. LSA encourages STEM participation through efforts such as the “Latinas in the Sciences” Panel discussion as well as directing students towards the “Emerging STEM Talent”
program which offers students additional mathematics problem solving opportunities in order to increase minority student success in higher level STEM coursework.

*Questbridge Scholars Program.* This scholarship program links high achieving, low income high school students with selective universities by providing financial and others forms of support throughout the college application process, during university and into the workplace. The program has several facets such as the “college-prep” scholarship which offers free test (SAT/ACT) prep, funded trips to visit colleges, an invitation to attend the National College Admissions Conference, assistance in completing college applications and full scholarships to college summer programs. Each year, Woodard College admits between 30-40 students who are a part of the Questbridge Scholars network.

*Mellon Mays Undergraduate Fellowship.* At Woodard College, fellows participate in a weekly seminar class in their second year which focuses on the role of minority people groups and the historical development of their intellectual heritage. Students are assigned a faculty mentor with whom they will engage in research during the final two years of university which better assists and better prepares fellows for future PhD study. On a national level, minority participants in the Mellons Mays program have a high rate PhDs completion (Prenovitz et al., 2015).

**Cahill University**

Cahill University is a coeducational college located in a rural area of the Mid-East section of the United States. Its engineering school is highly ranked and more than 30% of engineering majors at Cahill are women. The social life at Cahill is primarily centred on fraternities and sororities which are comprised mostly of White students. Compared to the other colleges in this study, Cahill University is the least ethnically
diverse, yet they do offer a wide array of programs for students from ethnically and socially diverse backgrounds.

*Success in Engineering Initiative (SIE).* This program offers academic support and professional opportunities for students who come from under-resourced high schools and who plan to major in engineering. Many who participate in SIE are URM students. This program offers group and one-to-one tutoring in mathematical concepts that are foundational to the continued study of engineering. Students can participate in this initiative all throughout college. This program not only offers assistance in sharpening mathematical skills but also offers camaraderie amongst students from similar backgrounds and who face similar challenges. Additionally, students are given the opportunity to be mentored by a working professional engineer as well as offered the prospect of internship opportunities with engineering firms that partner with the program. SIE is located in a dedicated space in the engineering building on campus and is run by a full-time director.

*URM Peer Mentor Program.* URM first year students are invited to participate in this year-long mentorship program. This program partners first year URM students from under-resourced backgrounds with URM mentors who are third or fourth year students at Cahill and who have ideally participated in the program as a mentee. Mentors receive extensive training and are expected to develop deep and meaningful relationships with their mentees assisting them in the academic and social transition to life at this residential college. Student mentors receive a stipend and are expected to mentor only one entering student over the course of the year.

*National Society of Black Engineers (NSBE).* Although several of the colleges in this study have NSBE chapters on campus, the Cahill chapter appears to be not only very active but a powerful force in the life of its participants. At Cahill, there are
approximately 30 Black students who participate in this society. Students are active in attending local and national conferences and receive funding to send a delegation each year to the national conference that return energised to build into their local chapter. This student chapter of NSBE benefits from strong student leadership.

*Society of Women Engineers (SWE).* This large influential group works at building camaraderie amongst the female engineering students at Cahill through study breaks, field trips and community outreach. Funding is provided for travel to national conferences.

*Society of Hispanic Professional Engineers.* This small student-led group works to encourage academic and professional development for engineering students from a Latino background.

*Multi-cultural Student Services (MSS).* This umbrella organisation houses cultural groups such as the Black Student Union, Caribbean Student Association and Organisation for Hispanic and Latin American Students. The aim of MSS is to provide support, mentorship and promotion for URM students while offering cross-cultural learning opportunities for students from all racial groups.

*EMB Fund.* Upon successful application, this fund provides monies to URM students to underwrite activities such as research opportunities, internships and tutorials in which they have been historically underrepresented.

*Summer Research Program.* Similar to initiative at other colleges, Cahill offers students the opportunity to participate in on-campus research with a faculty mentor. During this eight-week summer program, students work on a STEM related area of interest while earning a stipend. At the conclusion of the program, students are required to present their results in a campus research symposium.
**STEM Residential Learning Community.** Any student interested in STEM can choose to live on a residential floor of a dormitory with other students with similar interests. Students who choose this living option participate in STEM related workshops, seminars and activities with other students from this specific learning community.

**Posse Scholars Program.** Cahill University participates in this national scholars program which each year sends a contingent of approximately ten under-served, low income high school students from one locale in the U.S. to study at college together as a “posse” on full scholarship at their host institution. Fifty three different colleges and universities participate in this national program which identifies highly talented urban youth who may otherwise be overlooked or under-resourced in the college application process. The Posse program assists them in gaining admission to some of America’s most selective colleges. Upon successful entry into the program during high school, Posse scholars receive extra-supports and additional mentoring throughout college. Since scholars who attend a particular university all come from the same city, they are able to form a smaller inclusive community with others from the same geographical region both before and during college. At Cahill, Posse scholars participate in an annual retreat and are also assigned a local Posse mentor who is a professor at Cahill who may also be a minority faculty member. Once a scholar matriculates at Cahill University, this full-tuition Posse scholarship is not transferable to another college or university.

**Creswell College**

The most selective of the participating colleges in this study, Creswell College is located in a suburban area of a major city located on the Eastern seaboard of the United States. The curriculum offered at Creswell includes both liberal arts and engineering.
An honors program, which includes a two-year independent study that is examined by outside scholars, is offered for highly accomplished students. In recent years, 25% of biology majors and 40% of physics majors went on to earn PhDs. The campus culture encourages students and faculty to engage in open discussion on issues of inclusion, diversity and the development of meaningful community. There are several centres, institutes and groups that foster diversity as well as initiatives that support STEM students.

*Summer Research Program.* Apart from on-campus opportunities, Creswell funds students to also participate in research outside the college or even abroad during the summer months. Students may submit proposals for field work, internships, and research projects. Although URM students may apply for any summer opportunity, the Howard Hughes Medical Institute dedicates ten fellowships in STEM related research specifically for URM and first-generation students, groups traditionally under-served in STEM. These fellowship positions offer a generous stipend.

*Mellon Mays Undergraduate Fellowship.* The objective of this national program is to increase the number of minority students who eventually pursue PhDs. At Creswell College, five new Mellon Mays Scholars are chosen each year. This program offers ongoing mentorship throughout college with a faculty mentor, a stipend and participation in national programs. Selected students are additionally supported throughout their PhD with research and travel grants as well as though offerings at national conferences with other post-graduate fellows.

*Girls in STEM Conference.* Creswell sponsors this day long conference for girls from the local community to learn about STEM and engage in fun experiments. The goal of this outreach event is to encourage more girls, particularly girls of colour, to
experience hands-on learning in STEM. Creswell students also engage with these middle-school female participants by discussing topics centred on gender and science.

*Calculus STEM Support Group.* This group functions to assist students who plan to pursue a minimum of four university mathematics subjects during college yet who start their college mathematical journey lacking the skills to begin in calculus, which is often the entry mathematics subject for STEM majors. For URM students who come from under-resourced high schools and who may lack the mathematical background to begin in a STEM major, this support group, which meets weekly to develop mathematical thinking and skills, may help URM students to develop the capability necessary for future success in a STEM major. This group is run by a URM mathematics faculty member.

*Computer Science Peer Mentors Program.* With the goal of increasing participation of women and minorities in computing majors, Creswell College directs a peer mentor program in the computer science department. Teams of student mentors assist in classes and labs and also run evening group study sessions. This program has increased the participation of students who are usually underrepresented in computer science. This program is overseen by a full-time director.

*Residential Academic Mentors (RAM).* These student mentors and academic peer tutors are assigned to the various residential dormitories. These third or fourth year students are selected and trained to assist younger students who may be lacking in time management and study skills. In 2015, of the 27 RAMs, 21 were majoring in a STEM related field.

*The Black Cultural Center.* This dedicated cultural house ensures that the Black community at Creswell is an integral part of the campus community and an expression of the college’s commitment to embrace diversity while maintaining a multi-cultural
environment. Under the umbrella of the Black Cultural Center, multiple social groups exist as well as a chapter of NSBE. The centre offers first-year student and orientation programs, leadership retreats and a final year awards banquet for students of African descent.

**Hayden University**

Hayden University is a small liberal arts college located in the southern region of the United States. Situated in an urban area, and in close proximity to several other higher education institutions, Hayden University is one of the oldest HBCUs in the United States. It possesses an enduring legacy of excellence with a strong emphasis on liberal arts and sciences. Many notable African Americans are alumni of Hayden University.

Hayden University’s demonstrated commitment to STEM is displayed not only through its college level programs but also through the support structures offered at the individual student level, as well as its involvement in STEM efforts aimed at the local community. Hayden’s accomplishments in STEM have received national recognition. Over the last five years, in cooperation with a local major research institution, Hayden University has participated in the award of more PhDs to minority students in physics, astronomy and material sciences than any other institution. This “cooperative linking program” is one of the most productive PhD programs for URM students in the STEM disciplines of physics, astronomy and material sciences. By creating a path for undergraduate finishers towards completion of a STEM PhD, this exceptionally successful program, funded through NSF’s Broadening Participation program, is a model that other universities are working towards replicating. Additionally, they are the only HBCU to have won four R&D 100 awards.
Hayden University offers several programs at the undergraduate level that assists STEM students towards success generally, as well as specifically in their academic disciplines. This next section highlights these programs.

**Pre-College Bridging Program.** With the goal of increasing persistence for students entering Hayden University, this six-week residential program is offered the summer before college matriculation. This program focuses on academic, cultural and social readiness for college. In particular, a specific emphasis of the program is on increasing quantitative skills and critical thinking and analysis. Additionally, participants serve as volunteers in the community during their six-week tenure in the program. This pre-college program not only provides academic support for matriculating students, but also offers academic coaching, tutoring and mentoring during a student’s first year of college.

**Annual Research Symposium.** This longstanding two-day annual symposium is a place where students and faculty can share their recent research results with peers and also the wider university community. This symposium encourages students to engage in research and scholarship activities. Student-level research prizes are also awarded at this symposium.

**Achieving Excellence For All Program (AEFA).** This program oversees and coordinates the different campus initiatives that are in place to aid academically struggling students as well as those students who desire to increase their academic skills. Several of the different program components are listed below:

- **Advising.** Working in tandem with the role of academic advisors, AEFA sponsors workshops open to all students that help them with time management, test-taking strategies and college study skills.
• **Living Learning Centres (LLC)- Residential Peer Tutoring.** The LLC exists to help students become better equipped learners. These centres are located in the residence halls and offer one-to-one tutoring, structured study opportunities, study groups and academic coaching.

• **Early Interface** services. This service can be initiated by either a student or a faculty member. Faculty and academic advisors who believe that a student needs additional academic assistance can refer a student for services such as tutoring, Writing Centre assistance or Math Lab help. In addition, faculty and academic advisors interface with the Living Learning coordinators through the residential program to ensure that the student is receiving the needed assistance.

**LEAD Program.** The LEAD program on Hayden’s campus is a national initiative funded by the U.S. government to increase the number of minority students graduating from college. Participants must be first-generation college students who meet federal income guidelines (low SES) and who present with academic need. The program provides tutoring, financial-aid counselling, personal and career counselling, academic skills enrichment and peer mentorship. At Hayden University funding is available to serve 200 students through this program. With an undergraduate enrolment of less than 1000 students, this program could benefit a notable percentage of undergraduate students.

**Supplemental Instruction (SI).** This academic support model was first introduced at the University of Missouri and has been adopted by many universities in the United States. This proven model uses peer-assisted study sessions for students in courses that are traditionally considered difficult, such as introductory level and intermediate level science classes, classes in which a high proportion of students withdraw or fail, and exit
STEM. The study sessions are led by students who have already taken the course and performed well. SI leaders receive training for this role, attend all the lectures for the courses that they will peer-assist, and are paid. At Hayden University, several STEM subjects require mandatory SI participation for all students enrolled, not just those students who desire additional assistance.

*Summer Research Program.* After their first year of undergraduate study, students majoring in physics, chemistry, mathematics or engineering have the opportunity to spend the summer on-campus engaged in research with a professor at Hayden. This program is application based and students who participate are paid a stipend and offered housing.

*NSF HBCU-UP Project.* According to the National Science Foundation (NSF, 2016), “The Historically Black Colleges and Universities Undergraduate Program (HBCU-UP) is committed to enhancing the quality of undergraduate STEM education and research at HBCUs as a means to broaden participation in the nation's STEM workforce”. At Hayden University this NSF funded research based project exists to increase opportunities for URM STEM students towards future careers in mathematics, biology and computer science. Six to eight students are chosen each summer for this eight-week research program. Selected students are required to have taken several specific computer science, biology and mathematics classes as prerequisites for the program. Students earn a generous stipend as well as support for participation in academic conferences to present their research. The experiences gained through this program can certainly add to a student’s professional portfolio thus helping in securing a future STEM job.
Minority Access to Research Careers (MARC) Program. Offered at Hayden University, this program funded through the National Institutes of Health advocates its goal of preparing URM students with the skills and abilities to gain access to and graduation from PhD/Doctorate programs in Biomedical Sciences. Beginning as early as their first year of undergraduate study in the sciences, students can indicate interest in this program that includes professional development activities, career guidance, and monthly on-campus gatherings with nationally recognised scientists. Students who are successful applicants to this program (MARC Scholars) receive scholarships for their last two years of study as well as research opportunities with faculty during the academic year and off-campus research during summers between academic years. 

Students in this program have the opportunity to network with other MARC Scholars throughout the United States as well as present their research findings at national conferences in addition to the national meeting of minority biomedical scientists (ABRCMS). This program provides its participants opportunities for peer mentorship and relationships with role models who share a similar passion for biomedical science with a desire to contribute to improving health through research endeavours.

Hayden University also provides pre-professional STEM related programs to its students preparing for future studies in medicine, dentistry, nursing, pharmacy and engineering. Students interested in those specific STEM professional degree programs will complete three years at Hayden University and either two or three years at a partner institution. The partner institutions for medicine, dentistry and pharmacy are also HBCUs and these related programs require three years of study at the partner institution beyond the three years at Hayden. Students will receive both a bachelor degree from Hayden and a doctorate from the HBCU partner institution upon completion. Students
pursuing professional degrees in nursing (masters) or engineering (bachelor) will complete their studies post-Hayden at a partner PWI Research University.

The Missile Rocket Team (MRT) at Hayden University is an extracurricular endeavour in which students create and launch rockets. In national competition, Hayden’s MRT has outperformed other university teams whose students are members of aeronautical engineering departments, a discipline not offered at Hayden. Participation in the MRT has paved the way for several URM STEM students to secure internships and scholarships with NASA.

Though not explicitly directed at URM undergraduate students in STEM, Hayden University supports several community-based STEM initiatives which expand its commitment to STEM more broadly. With a focus on the next-generation of STEM scholars, the Urban STEM Teachers Academy (USTA) is an initiative of Hayden in partnership with another local research university. This project seeks to provide middle and high school science teachers with professional development opportunities to create hands-on curriculum for students in the areas of robotics, computer coding and rocketry. The goal of the program is to improve the academic performance of urban URM youth in science subjects through enhancing teachers’ skills with the hope of expanding the pool of future URM students in STEM higher education. Two other community based outreach initiatives spearheaded by Hayden are the Girls for STEM Program and the Boys for STEM Program. These 8-week summer, gender-specific programs are exclusively for youths in grades 5-12 who come from the urban area surrounding Hayden University. These programs offer academic skill building in mathematics and science through hands-on exploratory activities with the aim of improving self-confidence for girls and boys in science.
## Summary of Student and STEM Related Programs Offered at Each Participating Institution

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<th>PROGRAM</th>
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<th>HBCU</th>
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<td>Annual Research Symposium for Students.</td>
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<td>Community on Diversity in the Sciences (with students, faculty and staff)</td>
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<td>Computer Science Peer Mentors Program</td>
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<td>Early Intervention services</td>
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</tr>
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<td>Missile Rocket Team</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Society of Black Engineers (NSBE)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>NSF HBCU-UP Project</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outreach STEM programs for community</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Posse Scholars Program</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-College Program/Bridging Program</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantitative Skills Centre</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Questbridge Scholars Program</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Programs (Academic Year)</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Residential Peer Tutoring</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Society of Hispanic Professional Engineers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Society of Women Engineers (SWE)</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>STEM Peer Tutoring Program</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM Residential Learning Community</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM Scholars program for URM and First Gen</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>STEM Teachers Academy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success in Engineering Program (maths tutoring &amp; professional industry based mentoring)</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Summer Research Program</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Summer Residential STEM program for HS girls</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplemental Instruction (SI)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Travel Funding for Conferences</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Undergraduate Research Opportunities Program (UROP)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underrepresented Students in STEM Group</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>URM Peer Mentor Program</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*National Program; * Currently in place but not offered to current study participants due to initiative start date ;
Women’s colleges: Whitt & Woodard; Coeducational Colleges: Cahill & Creswell; HBCU: Hayden
Summary

While the institutions of higher education discussed in this chapter display unique characteristics and learning environments, there are many similarities not only in the various national and local programs offered at each college, but also in their collective commitment to improve the success of URM women in STEM.

Although this chapter highlights a variety of student level and STEM specific programs at each of the colleges, not every program at every college was discussed in detail. Table 8 presents a summary of the breadth of the programs and initiatives offered by and across each college. Since this chapter provides an overview of the institutional settings in which the quantitative and qualitative results of this study were embedded, the higher education environments also become objects of analysis. In the next chapter, the results of this study will be disseminated and framed by the quantitative and qualitative methods employed in this study. This will be followed by the Discussion chapter, in which a further synthesis of this chapter’s findings and the findings from the Results chapter will be further explored as institutional environments may offer a contextual dialogue on how settings, resources, and networks are experienced, invested and reproduced as capital (Krarup & Munk, 2014).
Chapter 5: Results

Using a mixed-methods research design, this study explored the experiences of URM female STEM students at five private liberal arts colleges. For comparative analysis, data was collected from both URM and non-URM female STEM students, and comparisons were drawn between these two groups of students. Further comparisons were made between URM female STEM students based on the type of college they attended (coeducational, women’s or HBCU). The analyses undertaken in this chapter sought to explore each of the specific research questions posed in this study with the aim of gaining a better understanding of how the organisational environment and social practices experienced by URM female STEM students generally, and at different types of private liberal arts colleges in the US, affected their persistence in STEM fields of study.

In this chapter, the results are presented in five sections. Each section corresponds to one of the five guiding research questions. Both quantitative and qualitative analyses are presented together in each section with the aim of illuminating complementary facets of the research results. The first section investigates the pre-college background and inherited cultural capital of both URM and non-URM female STEM students. The second section explores the college environment, college experiences and resourceful relationships as experienced by both URM and non-URM female STEM students across college types, and by URM female STEM students between college types. The third section highlights the impact of campus environments and ethnic identity, as well as aspects of inherited cultural capital on the acquisition of specific attributes of cultural capital attained during college. The fourth section explores how science identity for URM female STEM students may be shaped by the campus environment and experiences that occur during the college years. The fifth section
explores the effects of relationships with influential others, most notably family and mentoring relationships, on the persistence of URM female STEM students. The chapter concludes with a summary of findings.

**Pre-College Background and Inherited Cultural Capital**

In this study, URM female students who persisted in STEM were statistically more likely to come from homes where both parents were less educated, from families who earned less income, where both parents were less likely to be in a STEM occupation, and where parents were less involved in their daughter’s secondary school education when compared to their non-URM counterparts (see Table 9 and Table 10). In assessing the educational background of parents, 40% of mothers and 48% of fathers of URM female STEM students did not complete a bachelor’s degree compared to 20% of mothers and 18% of fathers of their non-URM counterparts. Parents’ educational expectations, however, were similar for both URM and non-URM cohorts. So for these young women of colour who appeared to lack a sense of inherited family capital, where did the motivation and resources to pursue STEM come from?

Overall, URM female STEM students appeared to be less academically prepared than their non-URM counterparts. As displayed in Table 9, and of significant note, URM female STEM students completed less STEM courses, less Advanced Placement (AP) STEM courses and achieved a lower GPA during secondary school. However, there was a statistically non-significant difference between URM and non-URM female STEMS students in the completion of AP Calculus during high school (see Table 10).
Of the URM women interviewed in this study, almost half (13 of 30) did not feel adequately prepared for the rigours of STEM study at college.

I was not at all prepared [for STEM in college], I think... it was really just like regurgitation and a lot of just like going through the motions...[In high school] my Biology teacher was bad. My Math teachers were good. And so as long as you like did the homework and turned it in, you didn’t have to learn anything to just get by and be a nice person. So I don’t think I really retained anything. Umm definitely having calculus helped me. I think that’s about it. It’s really sad. W7

I wasn’t prepared so, it’s been a struggle...my school didn’t offer calculus-- like the highest math was like pre-Calc. AP or any of these classes were not offered to us. Uh, I took Physics in high school. And that was a little bit helpful but like the rigor at college like literally, first day I started, I wasn’t ready for it. W8

I found that it was very, very hard in these intro classes when they say you don’t need any knowledge of chemistry or any knowledge of biology. I learned really quickly that that’s a lie [laughter]. You need some sort of background and so I feel like a lot of students of colour struggle just to be mediocre and that becomes really frustrating. W13

---

### Table 9

**Mann-Whitney U Test Comparing Selected Pre-college Variables for URM and Non-URM Female STEM Students (N=447)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>URM (n=94)</th>
<th>NonURM (n=353)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mdn</td>
</tr>
<tr>
<td>Mother’s Educational Level a</td>
<td>4.30</td>
<td>5</td>
</tr>
<tr>
<td>Father’s Educational Level a</td>
<td>4.03</td>
<td>5</td>
</tr>
<tr>
<td>Mother’s Educational Expectations b</td>
<td>1.38</td>
<td>1</td>
</tr>
<tr>
<td>Father’s Educational Expectations b</td>
<td>1.39</td>
<td>2</td>
</tr>
<tr>
<td>Family Income c</td>
<td>2.60</td>
<td>3</td>
</tr>
<tr>
<td>Total College Application support d</td>
<td>2.93</td>
<td>3</td>
</tr>
<tr>
<td>Total Parental Involve during HS</td>
<td>2.16</td>
<td>2</td>
</tr>
<tr>
<td>Educational Expectations for students e</td>
<td>2.84</td>
<td>3</td>
</tr>
<tr>
<td>Total STEM AP courses completed</td>
<td>1.40</td>
<td>1</td>
</tr>
<tr>
<td>Total STEM courses completed</td>
<td>5.60</td>
<td>6</td>
</tr>
<tr>
<td>HS GPA f</td>
<td>4.14</td>
<td>5</td>
</tr>
</tbody>
</table>

a 1-less than HS; 2-HS diploma; 3-some college; 4-associate degree (2 yr); 5-bachelor’s degree; 6-graduate degree  
b 0-none; 1-finish bachelor’s degree; 2-finish graduate degree  
c 1 <60K; 2 between 60-80K; 3 between 80-100K; 4 between 100-150K; 5 >150K  
d range 0-6; e 0-just finish HS; 2-some college; 3-finish college; 4-advanced study/graduate degree  
f 5=A/A-; 4=A/B+  

***p<.001; **p<.01; * p<.05; Effects sizes: small r=.10; medium r=.30; large r=.50
Table 10

**Chi-Square Values for Selected Background and Pre-College Variables for URM and non-URM Female STEM Students (N=447)**

<table>
<thead>
<tr>
<th></th>
<th>URM n=94</th>
<th>non-URM n=353</th>
<th>Chi-square $\chi^2$</th>
<th>pValue</th>
<th>$\phi$ (ES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-Generation College Student</td>
<td>29%</td>
<td>11%</td>
<td>17.662</td>
<td>.000***</td>
<td>.20</td>
</tr>
<tr>
<td>Mother in STEM Related Occupation</td>
<td>14%</td>
<td>25%</td>
<td>5.229</td>
<td>.022</td>
<td>.11</td>
</tr>
<tr>
<td>Father in STEM Related Occupation</td>
<td>28%</td>
<td>41%</td>
<td>5.657</td>
<td>.017*</td>
<td>.11</td>
</tr>
<tr>
<td>Attended STEM Enrichment in HS</td>
<td>18%</td>
<td>21%</td>
<td>0.263</td>
<td>.608</td>
<td>.02</td>
</tr>
<tr>
<td>Completed AP Calculus</td>
<td>61%</td>
<td>67%</td>
<td>1.522</td>
<td>.217</td>
<td>.06</td>
</tr>
<tr>
<td>Encouraged in HS by peers to:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>67%</td>
<td>79%</td>
<td>5.963</td>
<td>.015*</td>
<td>.12</td>
</tr>
<tr>
<td>Get good grades</td>
<td>90%</td>
<td>93%</td>
<td>0.502</td>
<td>.479</td>
<td>.03</td>
</tr>
<tr>
<td>Finish HS</td>
<td>90%</td>
<td>90%</td>
<td>0.000</td>
<td>.987</td>
<td>.01</td>
</tr>
<tr>
<td>Continue education</td>
<td>93%</td>
<td>89%</td>
<td>1.043</td>
<td>.307</td>
<td>.05</td>
</tr>
<tr>
<td>Finish college</td>
<td>80%</td>
<td>88%</td>
<td>4.008</td>
<td>.045*</td>
<td>.10</td>
</tr>
<tr>
<td>Encouraged to attend college by:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parents</td>
<td>94%</td>
<td>96%</td>
<td>0.755</td>
<td>.385</td>
<td>.04</td>
</tr>
<tr>
<td>Siblings</td>
<td>48%</td>
<td>50%</td>
<td>0.086</td>
<td>.769</td>
<td>.01</td>
</tr>
<tr>
<td>Other Family</td>
<td>51%</td>
<td>51%</td>
<td>0.000</td>
<td>.990</td>
<td>.00</td>
</tr>
<tr>
<td>Friends</td>
<td>67%</td>
<td>79%</td>
<td>6.289</td>
<td>.012**</td>
<td>.12</td>
</tr>
<tr>
<td>Teachers</td>
<td>84%</td>
<td>88%</td>
<td>1.100</td>
<td>.294</td>
<td>.05</td>
</tr>
<tr>
<td>Counsellors</td>
<td>72%</td>
<td>75%</td>
<td>0.357</td>
<td>.550</td>
<td>.03</td>
</tr>
<tr>
<td>HS or Support Program assisted with:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>College Application</td>
<td>66%</td>
<td>69%</td>
<td>0.410</td>
<td>.552</td>
<td>.03</td>
</tr>
<tr>
<td>SAT/ACT Prep</td>
<td>62%</td>
<td>49%</td>
<td>5.005</td>
<td>.025*</td>
<td>.11</td>
</tr>
<tr>
<td>Essays</td>
<td>60%</td>
<td>59%</td>
<td>0.027</td>
<td>.870</td>
<td>.01</td>
</tr>
<tr>
<td>Financial Aid Applications</td>
<td>43%</td>
<td>22%</td>
<td>15.989</td>
<td>.000***</td>
<td>.19</td>
</tr>
<tr>
<td>College Visits</td>
<td>32%</td>
<td>27%</td>
<td>0.718</td>
<td>.397</td>
<td>.04</td>
</tr>
<tr>
<td>Final College Decision</td>
<td>32%</td>
<td>24%</td>
<td>2.203</td>
<td>.138</td>
<td>.07</td>
</tr>
<tr>
<td>Parental Involvement during HS:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attended Parent/Teacher nights</td>
<td>62%</td>
<td>70%</td>
<td>2.176</td>
<td>.140</td>
<td>.07</td>
</tr>
<tr>
<td>Volunteered at school</td>
<td>18%</td>
<td>29%</td>
<td>4.444</td>
<td>.035*</td>
<td>.10</td>
</tr>
<tr>
<td>Parent/Teacher Assoc. meetings</td>
<td>18%</td>
<td>20%</td>
<td>0.102</td>
<td>.749</td>
<td>.02</td>
</tr>
<tr>
<td>Organised for tutoring</td>
<td>13%</td>
<td>22%</td>
<td>4.232</td>
<td>.040*</td>
<td>.10</td>
</tr>
<tr>
<td>Attended school events</td>
<td>67%</td>
<td>74%</td>
<td>1.939</td>
<td>.164</td>
<td>.07</td>
</tr>
<tr>
<td>Helped with homework</td>
<td>38%</td>
<td>45%</td>
<td>1.155</td>
<td>.283</td>
<td>.05</td>
</tr>
</tbody>
</table>

*p<.05; **p<.01; ***p<.001; Effect size (ES): small $\phi$=.10, medium $\phi$=.30; large $\phi$=.50

For those students who did feel adequately prepared for their STEM majors in college (17 of 30), the most common reason cited for this preparation was having had completed AP STEM courses during high school (15 of 17) or attendance at a STEM enrichment summer or semester programs during high school (2 of 17). Regardless of whether or not they sensed they were adequately prepared for the academic rigour of STEM at college, many URM female STEM students felt under-prepared for the pace of

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university-level STEM instruction and expressed frustration over their lack of study skills and time management skills, skills they wished they had learned in high school.

I’d say the speed, the speed at what you learn materials and also organization of materials. Umm, time management skills. They tried to teach it in high school but I think it’s just a different level in college because literally it’s a different thing altogether. High school versus college. So I think organization—that was a struggle for me. C4

I think everything was difficult for me when I got to college. In that transition I thought I was very prepared based on the classes that I took in high school. But they did not prepare me for the way that I needed to study to pass these classes in college. C5

Now, the biggest thing I think is they don’t set you up for time management once when you go to college, I think that’s where I really just couldn’t handle it my freshman year. I didn’t know how to study anymore. C6

Well it definitely took a while to fill those gaps. I always say my first two years here were like getting used to college and I feel like my junior [3rd] year is like the first year. I know how to study now. I know how to do things. I know how to get organized. I know how things work. So now I feel like I’m in a better space, but definitely coming in I don’t think I knew what I was doing. I was just kind of going with the motions and just not really knowing. It took like a year or so but I finally got there. W6

Although educational attainment for both mothers and fathers of URM female STEM students was significantly lower than non-URM female STEM students (p<.001) and URM female STEM students were almost three times more likely than non-URM female STEM students to be a first-generation college student (11% vs. 29%; p< .001, φ=.20), parents across both groups displayed near equal levels of academic aspirations for their daughters (see Table 9).

When reflecting back on their high school experience, URM and non-URM female STEM students reported receiving similar levels of peer support for getting good grades (90% vs. 93%), finishing high school (90% vs. 90%), and continuing their education (93% vs. 89%). Yet URM female STEM students received significantly
lower levels of peer encouragement when compared to their non-URM counterparts to study (67% vs. 79%, p=.015) or finish college (80% vs. 88%, p=.045).

Both URM and non-URM female STEM students received near equal levels of encouragement from family, teachers and counsellors to attend college (Median=3, U=14676, p=.081, r=.082) (see Table 10). However, when looking at the sources of support necessary to actually successfully complete the college application process, URM female STEM students received significantly greater levels of support outside the family with SAT/ACT college entrance exam preparation ($\chi^2(1) = 5.005, p=.025, r=.11$) and assistance in completing financial aid applications ($\chi^2(1) = 15.989, p=.000, r=.19$) than did non-URM female STEM students. In exploring the sources of this outside support during the interview process, it was discovered that more than half (16 of 30) of the interviewees participated in a community based or national “college-prep” program during high school. Of the ten first-generation URM students interviewed in this study, all but one (90%) participated in a college preparation program. These women credit these programs for not only preparing them for college, but also sustaining them through college and in STEM.

I was in a program, my four years of high school called Upward Bound. They came to my high school and I remember perfectly. They just said if you come to Upward Bound you’ll get into college, we’ll prepare you. So I gave it a shot. They helped with SAT prep, extra homework help, college applications totally. After I received my financial aid packages from all of the other colleges, the two directors helped me in making my decision. My mom didn’t have much to say. Uh, she did encourage me to stay in the program. She loved the program for me. But she didn’t understand what was going on; she just knew it was my ticket to college. W9

I was in this program called like the ACE Mentorship Program. So, it stands for, uh, Architecture, Construction and Engineering. It’s an after school program that met every other week but it wasn’t through the school. You actually went to different companies. I found out about it in my school. The actual companies are connected and they provide actual mentors. We have like projects that they’ve made up for us. So it was a team of students from other high schools in the city. This helped me to figure out what engineering was all about.W8
I was in this scholarship program during high school where they would send us off to visit colleges, so I visited Whitt College for a summer “science in engineering” program. The person who started the scholarship program chose certain high schools around my area that have a lot of underprivileged and underrepresented families and communities. I just saw an ad for it in my high school saying that there was a $5000 scholarship for each year of college, so that was what drew me in. This wasn't just like, uh, go to a meeting here and there. It was very intensive; meet with them every day. It was almost like having a separate class. They paid for ACT prep. They even paid for me to take the SAT. They paid for my AP tests. Yeah, it wasn’t just like academic support though. They are the ones who funded me to fly out not just to this college, but to the Ivys as well. They really formed my ideas of what college could be. W15

Well I was in the Memphis Prep Program. Well, they actually came to my school; they specialize in going to urban high schools, public schools. So they came and they recruited me from my school and I applied for the program. I got accepted. So I did that program and it was really good. My parents or no one in my family knew about college or knew about where to apply for college. So they were the ones that really played a major role. They actually helped me with a lot of my applications for college. They helped with ACT prep. I still talk to them and are still very close with them. W6

Although the URM female STEM students in this study may have lacked certain levels of cultural capital traditionally assumed as transferable from their families, they appear to have appropriated other sources of capital outside their families which assisted them in acquiring the knowledge and skills necessary for university attendance. URM female STEM students who persisted indicated that they appropriated more sources of outside support in the college application process than did non-URM female STEM students who also persisted (2.93 vs. 2.51, p<.10) (see Table 10). These sources of capital seem to have affirmed their preparation and motivation to pursue STEM at the university level. Many also formed relationships of trust with their high school guidance counsellors who assisted them in successfully navigating the college admissions process and in finding appropriate scholarship programs to finance their college education.

So my guidance counselor, I’ll never forget her. She was always trying to make sure that I would make it to college for sure. [Getting emotional]... but senior year, she said to me “there’s this scholarship I think you have to go for. It’s not guaranteed but you should go for it.” So I went for it, and I think there were maybe 1500 people in the first round of interviews. And then I made the first cut and it was down to like 100. And then I made the second cut which was 11 people. And then I got the scholarship [Posse]. So then I came here because of the scholarship—She was great.C5
When considering the types of secondary school attended, both URM and non-URM female STEM students attended private high schools at a rate of 30%, triple the U.S. national average of 10% (NCES, 2015) (see Figure 5). Also, URM female STEM students were almost twice as likely as non-URM female STEM students to attend a secondary school whose student body was comprised of a majority of minority students (see Figure 6).

![Type of High School Attended](image)

**Type of High School Attended**
- URM Female STEM Students (n=94)
- NonURM Female STEM Students (n=353)

*Figure 5. Type of high school attended by female STEM students*
For the 30 URM women interviewed, all but one (97%) had decided during or before high school that they would major in a STEM field in college. For some this was due to a family’s influence, or a general aptitude for maths and/or science, but for most this was attributable to the influence of a significant relationship with a high school maths or science teacher who encouraged them and affirmed their gifts in maths or science.

*My motivation [for STEM] came from a few places. Umm, high school was a big one. In high school, I was exposed to many STEM courses and—My high school, their focus is in Engineering and Math. And so I took an engineering curriculum. I had exposure to AP classes but I think two main reasons why I did, umm—why I decided to do Engineering. One is because I think throughout my time in high school, my perception of what teachers were saying at least—the summary is that you’re Black, you’re a woman, you should be an engineer just because you have the potential to be. C4*

*I think I decided my sophomore year of high school, when I took Advanced Placement Chemistry, and the teacher (female) that I had showed me that chemistry was something I was really good at—And that it was something that I enjoyed... I definitely knew that I wanted to be a Chemical Engineer from then... It is also nice to have a female teacher in the STEM field. C5*
When I came to college, I knew that I was going to major in a STEM field. I wasn’t exactly sure what STEM field I’d do so I came in undeclared, but I did the biology track. Biology was okay, I liked it, I got A’s but I feel like in high school, I really fell in love with chemistry. My chemistry teacher in high school was just amazing. And then I took AP chemistry, and I really loved it because I loved the geometry and the chemicals and just understanding the mechanisms of science. So I just always knew that I was going to do something in the science field. H3

So my Anatomy teacher, he just made it so interesting that I thought I have to become a Biology major. This is just too amazing, like not to keep going. H7

I think I knew my senior year of high school that I might major in a STEM field ...after I took AP Chem. And I realized that I really loved the little puzzle work that you have to do with it. I had taken a very superficial physics course in my junior year of high school. And that really got me going. I did a whole bunch of projects and I just really loved it. W2

The women interviewed for this study entered college with a strong inclination towards majoring in a STEM field. Additionally, only 4% of both URM (n=94) and non-URM female students (n=353) who were surveyed indicated that they switched into a STEM major after first declaring a non-STEM major in college. Regardless of ethnicity, women who persisted in STEM started in STEM.

College Environments, College Experiences and Resourceful Relationships

In the next section of this chapter, comparisons are made between URM and non-URM female STEM students in regards to college environments, college experiences and resourceful campus relationships. Then, assessing the same indicators, comparisons are then made between URM female STEM students based on the college type attended (women’s, coeducational or HBCU).

Comparisons between URM and non-URM female STEM students. In order to compare the experiences of URM and non-URM female students in STEM within a liberal arts college setting, a Mann-Whitney U test was run to compare specific aspects of college experiences, college support structures, perceptions of campus
environments and resourceful campus relationships for these two groups of students
(see Table 11).

Table 11
Comparing College Experiences, College Support Structures, Perceptions of Campus Environments and Resourceful Campus Relationships for URM and non-URM Female STEM students- Mann-Whitney U test (N=447)

<table>
<thead>
<tr>
<th></th>
<th>URM n=94</th>
<th>non-URM n=353</th>
<th>U</th>
<th>p</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>College Experiences</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seriously considered quitting college</td>
<td>2</td>
<td>2.46</td>
<td>1</td>
<td>1.91</td>
<td>13042</td>
</tr>
<tr>
<td>Seriously considered leaving STEM</td>
<td>3</td>
<td>2.80</td>
<td>2</td>
<td>2.25</td>
<td>12797</td>
</tr>
<tr>
<td>STEM classes too competitive</td>
<td>3</td>
<td>2.92</td>
<td>3</td>
<td>2.64</td>
<td>13709</td>
</tr>
<tr>
<td>College GPA</td>
<td>3.32</td>
<td>3.29</td>
<td>3.53</td>
<td>3.50</td>
<td>11188</td>
</tr>
<tr>
<td><strong>College Support Structures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Received Adequate Financial Aid (n=372)</td>
<td>a</td>
<td>4</td>
<td>3.77</td>
<td>4</td>
<td>3.40</td>
</tr>
<tr>
<td>Acquired Cultural Capital Factor</td>
<td>b</td>
<td>3.8</td>
<td>3.75</td>
<td>3.8</td>
<td>3.77</td>
</tr>
<tr>
<td>Receive academic prep for successful STEM career</td>
<td>4</td>
<td>3.86</td>
<td>4</td>
<td>3.96</td>
<td>14993</td>
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<tr>
<td>Receive career advice for successful STEM path</td>
<td>4</td>
<td>3.54</td>
<td>3</td>
<td>3.29</td>
<td>13966</td>
</tr>
<tr>
<td>College preparing me well for chosen career path</td>
<td>4</td>
<td>3.71</td>
<td>4</td>
<td>3.83</td>
<td>15234</td>
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<tr>
<td>Possess skills to get admin questions answered</td>
<td>4</td>
<td>3.74</td>
<td>4</td>
<td>3.84</td>
<td>15435</td>
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<tr>
<td>Know where to go if I need help or falling behind</td>
<td>4</td>
<td>3.92</td>
<td>4</td>
<td>3.95</td>
<td>15958</td>
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<tr>
<td><strong>Perceptions of Campus Environments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Racial Climate Factor</td>
<td>c</td>
<td>2.25</td>
<td>2.43</td>
<td>1.5</td>
<td>1.64</td>
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<tr>
<td>Due to ethnicity felt alienated on campus</td>
<td>2</td>
<td>2.42</td>
<td>1</td>
<td>1.60</td>
<td>9806</td>
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<tr>
<td>Due to ethnicity felt alienated in STEM classes</td>
<td>2</td>
<td>2.60</td>
<td>1</td>
<td>1.56</td>
<td>9174</td>
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<tr>
<td>Experienced racial discrimination from teachers</td>
<td>2</td>
<td>2.04</td>
<td>1</td>
<td>1.49</td>
<td>10956</td>
</tr>
<tr>
<td>Experienced institutional discrimination</td>
<td>3</td>
<td>2.65</td>
<td>2</td>
<td>1.92</td>
<td>11114</td>
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<tr>
<td>Early STEM Academic Belonging Factor</td>
<td>b</td>
<td>3</td>
<td>3.13</td>
<td>3.5</td>
<td>3.42</td>
</tr>
<tr>
<td>Felt sense of academic belonging in first year</td>
<td>3</td>
<td>3.04</td>
<td>3</td>
<td>3.22</td>
<td>14740</td>
</tr>
<tr>
<td>Felt sense of academic belonging in second year</td>
<td>3</td>
<td>3.21</td>
<td>4</td>
<td>3.63</td>
<td>12388</td>
</tr>
<tr>
<td>Campus takes diversity issues seriously/effect programs</td>
<td>3</td>
<td>3.23</td>
<td>3</td>
<td>3.41</td>
<td>14491</td>
</tr>
<tr>
<td><strong>Resourceful Campus Relationships</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquired Social Capital Factor</td>
<td>a</td>
<td>4</td>
<td>3.97</td>
<td>4.2</td>
<td>4.18</td>
</tr>
<tr>
<td>Advisor/Mentor source of academic encouragement</td>
<td>4</td>
<td>3.96</td>
<td>4</td>
<td>4.17</td>
<td>14267</td>
</tr>
<tr>
<td>Teachers source of academic encouragement</td>
<td>4</td>
<td>4.10</td>
<td>4</td>
<td>4.38</td>
<td>13302</td>
</tr>
<tr>
<td>Formed relationships of trust to help me graduate</td>
<td>4</td>
<td>3.89</td>
<td>4</td>
<td>4.18</td>
<td>13753</td>
</tr>
<tr>
<td>Classmates source of academic encouragement</td>
<td>4</td>
<td>3.80</td>
<td>4</td>
<td>4.08</td>
<td>13968</td>
</tr>
<tr>
<td>Better prepared to handle setbacks than in HS</td>
<td>4</td>
<td>4.10</td>
<td>4</td>
<td>4.12</td>
<td>16081</td>
</tr>
</tbody>
</table>

Note: Mdn = Median; M =Mean

Medians - 1: strongly disagree; 2: disagree; 3: neither agree or disagree; 4: agree; 5: strongly agree
a. only 372 students indicated that they were financial aid recipients
b. Scale for Factors, range 1-5, negative (1-2); neutral (3); positive (4-5)
c. Scale for Racial Climate Factor, range 1-5, positive (1-2); neutral (3); negative (4-5)

*p<.05; **p<.01; ***p<.001; Effect size (ES): small r=.10; medium r=.30; large r=.50

Although female students in this sample had persisted in their STEM majors for a minimum of two years, they were asked if at some point during college they seriously considered quitting college or leaving STEM. While the majority of students from both URM and non-URM groups indicated that they had not seriously considered either of

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those options, 30% of URM female STEM students did indicate that they had seriously considered quitting college compared to 16% on non-URM female STEM students. Additionally, 40% of URM female students indicated that they seriously considered leaving STEM, compared to 23% on non-URM female students. While the majority of students in both groups did not indicate an inclination towards quitting college or STEM, the differences between the groups were significant, with both comparisons indicating a small effect size for these measures. Though they continued to persist and exhibit academic stamina, URM female STEM students were almost twice as likely to seriously consider quitting college or leaving STEM as their non-URM counterparts. A correlation analysis was run comparing URM female STEM students’ indication of seriously considering leaving STEM with all the predictor variables explored in this study. This analysis produced a significant correlation with seven variables (see Table 12). URM female STEM students’ indications that they seriously considered leaving STEM was most highly correlated to STEM competitiveness \((r = .426, p = .000)\).

### Table 12

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation Coefficient</th>
<th>(p)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM Competitiveness</td>
<td>.426</td>
<td>.000***</td>
</tr>
<tr>
<td>Science Identity</td>
<td>-.315</td>
<td>.003**</td>
</tr>
<tr>
<td>Racial Climate Factor</td>
<td>-.308</td>
<td>.003**</td>
</tr>
<tr>
<td>College GPA</td>
<td>-.302</td>
<td>.003**</td>
</tr>
<tr>
<td>Multi-Ethnic Identity Measure (MEIM)</td>
<td>.271</td>
<td>.009**</td>
</tr>
<tr>
<td>Early Academic Sense of Belonging in STEM</td>
<td>-.258</td>
<td>.013</td>
</tr>
<tr>
<td>Adequate Financial Aid</td>
<td>-.224</td>
<td>.037</td>
</tr>
</tbody>
</table>

*p < .05; **p < .01; ***p < .001

In comparing students’ perceptions of the competitiveness of STEM classes, both groups expressed an identical median value of three (neither agree nor disagree), though the mean ranks of each group differed significantly \((U = 13709, p = .017, r = .11)\). The interview data further revealed that URM female STEM students who attended a
women’s college appeared to be most vocal of their perceptions of the competitive nature of STEM.

I was in some ways afraid of the STEM major because I thought it’d be really difficult but I was almost afraid more of the people in the STEM major than I was afraid of the actual material itself. I was scared that my classmates were going to be terrifyingly competitive. In some ways, they were. W1

I think the types of people you encounter in the STEM fields in college, I mean, they’re just so intense. W2

Our academic culture I don’t think it’s supportive. I think it’s very much so competitive. W7

Although URM and non-URM female STEM students displayed a statistically significant difference in their self-reported GPAs, measures of mathematics self-concept between these two student groups were near equal. The mean self-reported GPA for URM female STEM students was 3.29 compared to the mean GPA of 3.50 for non-URM female STEM students ($U=11188, p=.000, r=.30$). This statistically significant result also displays a medium effect size. Though the grades earned in STEM were a source of discouragement for many of the women interviewed, receiving words of affirmation in the context of a trusted relationship assisted these students to refocus their understanding of academic success using a lens different than one based exclusively on grade based achievement.

It was one of those times where I was just not feeling great about my Biomedical Engineering path. I was like, “I think something’s really wrong here”. Not that I didn’t want to do it but I just was upset about at how my grades were going. My professor told me, “Your grades might not be the best, but you do work really well”. I do produce very good work. So how can my professor who actually does grade my work really tell me that? It was really nice. C3

I felt so insecure and the GPA was the thing that like messed me up the most... I wasn’t feeling good then I went to my professor and she told me, “You’re going to be fine. Everyone gets a C”. And she was very encouraging and said to me, “This is an academic journey and you’re going to do great. And you're doing really well. You're going to be fine.” W5

And after not succeeding academically so many times and what I mean by that is like a bad grade on an exam. Umm, knowing that and taking that information—going to office hours, going to a mentor, seeking help. And trying it again. Just this repetitive cycle and setting up in my mind that I can do it. C
Second semester I failed a course. So, after that I was just like --- I didn’t have confidence in raising my hand and saying the answers and I doubted myself a lot. But that was one professor in one course, I can’t let that kind of dictate my whole academic career but it did influence me a lot and I was very sad. You know in high school you got straight A’s then you come to college and you fail, you’re like, “I never even had a C in high school and I now failed a course.” For someone who is very much into their academics, it’s very hurtful. I think my parents were a big influence on how to move on. They are just like, “It’s okay. Calm down. It’s okay. It’s not the end of the world. Other students have failed.” Also, my academic mentor told me she failed a thermodynamics exam before and now she is a professor of thermodynamics. So I’m like, “Okay, you can turn this all around. It’s not an “all is lost” kind of moment. C2

In looking at involvement outside the classroom that is not assessed by grades, URM female STEM students participated in more curricular and extracurricular activities than did non-URM female STEM students, with medians of five activities versus four activities, respectively. Figure 7 highlights the types of activities in which female STEM students participated. Of significant note, URM females participated more than non-URM female STEM students in attending diversity clubs and events, 65% vs. 47%, \( \chi^2(1) = 9.784, \ p = .002, \ \varphi = .148 \), in volunteering, 73% vs. 63%, \( \chi^2(1) =5.254, \ p = .022, \ \varphi = .108 \ ) and in having a relationship with a professional mentor, 22% vs. 11%, \( \chi^2(1) =6.686, \ p = .010, \ \varphi = .122 \ ).

![Figure 7. Engagement outside the classroom: Percentage of female STEM students’ extracurricular participation by activity type](image_url)
For URM female STEM students who have persisted beyond their second year of STEM study, more than half (54%) have held an internship position and nearly two-thirds (64%) have participated in a research experience. Additionally, of the 30 students interviewed, half (50%) have attended and/or presented research results at an academic or professionally affiliated conference. For women of colour in STEM, attendance at conferences can help cast a vision of the possibilities of STEM beyond the context of the classroom or campus environment, and inspire optimism for the future where confidence in the present may be lacking.

Sophomore [second] year, I went to the SWE [Society of Women Engineers] conference in Houston, Texas and that just blew my mind at how many hundreds of women were involved and I think there were like 300 companies represented there, and all of them looking for female engineers to work, or female chemists to work or female biologists to work there. Umm, so I think that gave me an extra push in the hard times. C5

I was able to attend regional and national [NSBE] conferences. I felt like that was really encouraging because although I may not see the masses of minorities or females in the STEM fields, which I still didn’t see at the conference for females, but at least I had the opportunity to attend those and see that there’s a bunch of other students [of colour] out there that are in STEM, that they are working really hard and are struggling as well. So, it was good to see that and share those experiences with them. C2

The Jackie Robinson Foundation has really helped me because when I go there [annual conference] I see people who look like me, who are in similar situations, and they're also in a STEM field... And so just talking about it and understanding that I'm not alone in my struggles is really like a profound thing. W13

Many women of colour in STEM come from families where the cost of attendance at a private tertiary institution would be prohibitive without scholarships or financial aid. Overall, URM women in STEM were more satisfied with the financial aid packages they received from their colleges than were non-URM female STEM students ($U=9943$, $p=.004$, $r=.004$). Of the 30 interviewed students, four did not rely on financial aid or scholarships to fund their college education. Of the remaining 26 students who depended on financial aid and/or scholarships, 24 of the 26 (92%) believed that the financial aid they received provided sufficiently well for their education, though for a
few the process of applying for financial aid was riddled with confusion and “red tape”. For many, the financial aid package was the determining factor in their college selection decision.

I chose to come here for financial reasons, Yeah, yeah, financial aid. My college, they meet the full basic needs to attend school. After I received my financial aid packages from all of the other colleges, this college was just like it. They did offer me a lot. Yeah, and now with financial aid, when I ever have a question, I call the financial aid office, and they’ve helped me. W9

My college I attend now offered the biggest financial aid package... They have awesome financial aid. It takes pressure off my family because there’s no way my parents could help to afford this school... they knew they couldn’t help pay for me to go to school so it kind of makes more sense for me to go to a school that was offering me more money. So at that time when I was making my decision of where to attend, I just worked out that this college was better for me, and would not put that much pressure on my family. W8

I’m very appreciative of my financial aid -- appreciative of all the help they’ve given me. If it wasn’t for their package, I wouldn’t have been able to come here. So, they made it really affordable for me. Umm, but getting the financial aid, the experience really, really, really, was really not good. My parents, they’re supportive of me but their income is very low. They don’t speak English so, with all of these forms I had to fill out, my parents got really frustrated because they had to pay for translation. W14

So I actually applied to “N” University as well because I really liked it, but financially they’re not as nice. I also wanted to go to “D” University because I like the way their engineering program is structured, I just really like it. But then at the end it was like down to financial aid. And I mean my college here is like really, really good about it, so very generous. W4

While URM female STEM students began their tertiary educational experience with lower measured levels of family related cultural capital (parents’ education, parents’ occupations, SES) than did non-URM female STEM students, these two groups appear to possess near equal levels of cultural capital acquired during college when measured in the context of those skills and outcomes that were necessary to effectively navigate the academic milieu of STEM higher education (Median 3.8, U=15899, p=.756, r=.01). In particular, URM female STEM students reported receiving career advice for a successful career in STEM to a greater extent than did non-URM female STEM students (U=13996, p= .028, r= .10). The 30 URM female STEM students who
were interviewed believed overwhelmingly they were not only prepared well for a future career in STEM, but also prepared to be successful in life, and for many women, particularly those from women’s colleges, this seemed to be a more dominant theme than a simple appreciation of the specific knowledge and skills accrued within their STEM disciplines.

*I think my college provides amazing labs… I think they provide amazing opportunities to do research. They provide you with the career development center. They provide you with different, outside speakers, seminars. They really, really -- I think they’ve done an amazing job, 10 times better than my high school, um, with what I can do so I would say yes, they have prepared me for a successful career.* C6

*All the opportunities that they have definitely afforded me with and then all the connections that I’ve gotten from them setting me up with internships, me working in the lab upstairs, they’re definitely setting me up for a successful career.* H3

*Yes, I believe my college is preparing me [for a successful career in STEM]. The professors that we do have are pretty well-versed in their fields. And once they get to know you as a student, they push you for your abilities. So they don’t necessarily let you coast. If they know you’re capable of better, they’re going to make you do better.* H6

*I would say so that my college prepares women of color [for successful careers in STEM], yeah. I think just the classes are really good because we have a small class size, the faculty is pretty engaged with doing research projects with students and it’s very common I think for students to work on research projects with faculty. So, already going in to a work atmosphere or graduate school with research experience as an undergraduate is extremely valuable.* W10

*My college has prepared me for a successful career, but almost to a broader sense. I think my college has given me a lot of the tools to more understand myself. And to figure out a career even if it isn’t in my field, if it takes me somewhere else. Umm I know a lot of my friends who are at other institutions feel like they have to go into the field their degrees are in. Because they don’t know how to do anything else and I think while I do intend to go into Science and Biology and into those fields, but I look at my mother who graduated with a degree in Chemistry and ended up working at a consulting firm, successfully and happily. And I’m pretty sure that my college has given me the tools to say “Yes, I can make it in my field” but I can also make it somewhere else.* W1

*I feel like my college has prepared me really well. I feel like my ability to write scientifically and analytically very critically; it’s very important. Those are skills that I think I would take away from college. Also, how to navigate certain systems I think. I would also take away networking. And I think one of the larger ones is the environment, you know for a woman’s college. I think if I would have been at a large state university or a co-ed school, I don’t think I would’ve taken the leadership roles that I’ve taken here. I don’t really think so and I wouldn’t be so outspoken about my own self.* W17

*My college has definitely, definitely prepared me. They prepared me well, regardless if I do STEM or not. They prepare you for the world.* W8

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Both URM and non-URM female STEM students differed little in their self-reported levels of possessing the skills to get administrative questions answered on campus or knowing where to go to get help if they were falling behind. The median for both groups and for both prompts was four, indicating a positive agreement with both these statements. URM female STEM students appeared to know of the resources available to them on campus. For some students, visiting professors during office hours was critical, for others having a few key friends they could rely upon was vital, but for several, participation in a campus directed program was crucial to their success. As highlighted in the previous chapter, some of these programs were specifically geared to students of colour or students from lower socio-economic backgrounds, and some of these programs were campus wide initiatives for all students. The combination of these resources provided necessary avenues of support to encourage persistence for URM female students in STEM.

I’m not really sure how they go about it now but when I started, they [Success in Engineering (SIE) Initiative] picked particular students to be involved in it. And so, it was mainly minority students, Posse scholars were in it and other students as well. I’m not sure how they chose them but I just know we all were there. And so, that was really helpful as well because we got to see other faces that looked similar to ours and were in our classes. C2

Oh yeah, it [SIE] was helpful. I think that’s why I’m still here probably. Umm and it also gives you something that people don’t always consider—And having a group like SIE gives you the support system you need to feel confident in the power of your voice in the classroom... So most of the time, being a girl from an urban area, you’re not going to raise your hand in class, so SIE helped me. C5

We have what’s called a Teaching and Learning centre in the library where you can request tutors. They also have study groups. It basically goes by a section of your class. So I was taking – I’m taking Analytical Chemistry and so with my section, we have a study group so I can, you know, sign up for a study group of my class. Everybody in my class will be in that group. C3

For supports, there’s AEFA. I’m in the LEAD. Leadership and Academic Enrichment Program. So it’s like an Upward Bound at the college level. LEAD helps not only with academics but cultural diversities, exposing us to new things. AEFA is more of academic enrichment so if you need a tutor or supplemental help with this area or that area, they make sure that they have a nice roster of people with flexible schedules to help you out. H6
The support comes from your friends and people, your community that you built here, your professors. My biggest support systems come from my friends and professors. My professors, my adviser, but most of the time, it’s my friends. W8

I am aware of supports if I need them. Yeah, I mean and the thing is if I don’t, I know that I can ask friends or I can ask my various professors so if there’s something I don’t know, I know how to obtain the information. If it’s people I know, I certainly feel confident in initiating contact for help, if it’s like, yeah, if it’s people I’ve developed a relationship with. W16

Just about every single department has its own tutors for academic help. There’s the Quantitative Centre… where it’s for anything - Psychology, Math, Science, Physics. You name it they’ll find it for you. You know, so if you need the help they’re going to work with you. W9

I feel very supported. There are so many programs for me to reach out to and say, “Hey, I need help. Please help me.” W2

While many students were well aware of the programs and formal supports available to them on campus, the ability to initiate requests for needed support and self-advocate appeared to be a learned skill, often taking URM female STEM students a few years to master. Several students had attended non-academic summer bridging programs offered through their colleges that taught strategies for navigating various college systems and college life. Aside from those who participated in bridging programs, few of the interviewed URM female STEM students entered college with the confidence to readily utilise the support structures that were in place to assist them in finding success on campus and in STEM. Having come from secondary schools where many were at the top of their class, URM female STEM students felt overwhelmed by the perceived intelligence levels of their college peers and were intimidated from seeking help for fear of being considered less able. Often, students would seek help from peers first before engaging with professors or support sources. 

Within STEM, you do really have to go out and talk to your professors. I think that’s a good rule within friends, keeping you accountable. I know through SIE -- because my friend J who did start off as an engineer. So, both of us would be like, “Okay, we have to go to office hours even if we don’t like it.” We’ll be like, “Okay, you go to that one, I’ll go to this one. We’ll meet up again.” So, it was kind of like that kind of peer pushing each other to succeed that really was helpful for me in the beginning. C2
And I think college allowed me to see that it’s okay to ask for help, it’s okay to tell someone you don’t get something or you don’t understand something... So now, I schedule weekly meetings with professors if I’m falling behind. I’ve gotten tutors that I didn’t even know that are free for students to use and there are other students where there can be someone much older, a grad student or you can go and talk to your TA. So, I think once when I found the resources available, which there are so many, I was able to better prepare for my classes and be able to focus more.

So, I have to say that my ability to initiate support, that came a lot from the Achievement Scholars Program (ASP)... So, they are one of the things that really broke down the wall of being scared [of asking] for help. Yes, the ASP program, it definitely has helped me... before coming to college was a challenge because I came from high school being the top of my class and just like, “Oh, I know this.” So, now, I’m like in the middle or bottom. I don’t want to say I don’t know, I don’t understand.

For STEM or Physics—because my [high] school was so small, I wasn’t used to demanding help or attention. It was always just kind of there and everyone kind of went through the same thing, then I got to college and realized that you need to ask people for the resources you want. So that took me a couple of years to learn... I feel comfortable enough to go to certain students and be like hey, I’m actually struggling with this what do you think I should do and that kind of stuff.

For URM and non-URM students there was a significant correlation between students’ assessments of their colleges’ commitment to diversity and its’ effective programs with students’ perceptions of a positive racial climate ($r=.144$, $p=.002$). Compared with all other variables in this study, the perceptions of Racial Climate on campus displayed the greatest effect sizes and statistical differences when comparisons were made between URM and non-URM female STEM students. While neither group’s median response (2.25 vs. 1.5) for the Racial Climate factor was neutral or negative, the spread of the responses as indicated in Table 11 reveals a significant difference between the groups ($U = 8452$, $p = .000$, $r = .34$). Of the URM female students in STEM who were surveyed ($n = 94$) across the three college types (coeducational, women’s, HBCU), 33% indicated that they experienced feelings of alienation in STEM classes due to their ethnicity and 24% experienced feelings of alienation on campus due to their ethnicity. Within this same group of students, only 9% indicated that they experienced racial discrimination from a teacher; though 27% indicated that they had experienced some level of institutional discrimination. The majority of women of colour who persisted in
STEM have a somewhat positive perception towards the racial climates experienced in the classroom and on campus. Through the interviews, URM female STEM students shared openly of how their ethnicity affected their perceptions of feelings of inclusion or isolation on campus, and in STEM. For some, a certain theme emerged where URM female STEM students felt that non-URM students and faculty held lowered expectations towards them.

A lot of times people will say, “Oh, you probably got accepted because you were a Latina and they want to diversify the school.” Some people say that maybe they don’t look at your application as rigorously because they need those type of students. C6

Let’s say I’m sitting in a class and, a professor continuously asks [for] an answer from someone he knows knows the answer. Right. So the student is female, she’s White or she’s Asian. And he knows he’s going to get the right answer. So he won’t call on me because I’m Mexican-American. I think that does happen sometimes. And I think it does get on a lot of other students’ nerves. W2

... so from lab groups and people second guessing your work... I didn’t see them checking over White female student’s work and things like that, so yeah I took it personally because I’m a Black student and Black female in this field where there’s not many others that I need my work checked over... I think it shifted a lot also because freshman year I wasn’t as vocal... I did become vocal to other students and say like, “No, you’re going to have to wait,” or, “It doesn’t need to be checked over, it’s fine,” or “if you’re going to check over everyone’s then you can check over mine as well”. And I also think they also realize like I’m here, I’m going to be here, you’re going to see me next semester, I’m going to be sitting next to you again. So, I think just my presence alone in like, “Okay, wow, she is taking the same courses, passing the same classes as me. I shouldn’t doubt her or anything like that.” C2

Well definitely being the only Black girl in my classes, being the only Black girl in my lab or having moments where you’re assigned a partner and then you have moments where, you know, you’re talking with your partner and you’re trying to come up with calculations and then they doubt your answer and subconsciously you wonder if they doubted because they think you don’t know how to do it or—and then those glorious moments when you find out you’re correct and they’re wrong. W6

The experiences of racism both on campus and in STEM were deeply felt by several of the URM female students who were interviewed, yet the majority of students interviewed appeared to downplay the impact these racially sensitive encounters had on them personally. For some, this occurred in the context of processing these experiences with other students, particularly other classmates of the same ethnicity. But many of the
interviewed URM female students in STEM seemed to take minimal offense at what others might consider derogatory, racially-based interactions, choosing to believe that non-URM students’ comments came more from ignorance than from intentional harm or racist attack.

*I never really had any like bad experiences, I’ve heard of people who had like bad experiences…things that it felt always like racist or things like that… are mean or hurtful, because it is really they are uneducated…they might say things you really shouldn’t say…but it’s more so, one of the things that you just correct them rather than like, oh she said this, I will report you. It’s more so just educating them. They honestly maybe just don’t know.* W8

*Because of my culture, sometimes people don’t get me a little bit. It’s just small things…. nothing has been insulting to me really. I mean, if it’s insulting, it’s not in a way where I felt someone was being aggressive but it’s just more insulting like they’re trying to get it and they don’t get it…. There’s a culture here where people try to understand each other’s backgrounds. Though, I don’t know how good of a job people do sometimes…But like, mostly I attribute that to people being really young and thinking that they know what they’re doing and really they don’t.* W10

*The STEM classrooms, they’re mostly White. I mean I’ve never felt, you know, singled out or out of place necessarily, at least not by anything that anybody has ever said or done in that regard.* W16

*I’m not really here to, you know, be a poster child for Black people. I’m here to get a degree— And do what I want to do. So I try to push that in my mind but there’s sometime where it does get to you when you finally take back and notice your surroundings.* C3

*The thing about what I see is that I don’t really pay attention to it [racism]. I don’t have ears for that or eyes. Which is good and bad. One, it is good because I don’t really let it affect me as other people do. But the other thing is that I don’t really know the degree of insult that it is. So probably the people who are doing it will keep doing it until I notice it.* W17

When asked during the interviews how their college could improve the success of women of colour in STEM, one of the most common responses was to increase the diversity within the STEM student body and faculty with the hope of potentially reducing the level of isolation experienced by URM women in STEM.

*I think hiring more professors that I know identify as Black or Latina or whatever it may be as underrepresented. I think that really helps. To feel more support because you could feel like they probably understand you.* W4

*There needs to be more women of color— Like, I don’t know, I really just want more professors who are women of color.* W7
I think they should have faculty members that are women of color. I think that would be very helpful. I mean because you can go to office hours and you can have connections with professors but I feel as though they don’t understand the same things that I face or don’t even think about it. They don’t really think like, “I wonder how she must feel being the only Black student in the whole grade.” They don’t see it as that, while I feel like maybe a faculty member of color would see it as that and also it would be an example, okay like, “She’s a woman of color. She’s teaching the course. I am capable of this. It’s not only White males and White females teaching me everything.” 

It would help that there are more women professors instead of just having all male professors. I think it would just make you feel a little bit more comfortable or make you feel like you can as well if there was also more diversity within the faculty --I just think that with anything, it’s like not an example, but if you see someone else -- if you see that someone else can, then you feel like you too can. 

I would love to see myself represented in this faculty. Or see more racial diversity.

For many women of colour in STEM, being involved with an ethnically based campus organisation allowed them to connect with others from similar backgrounds to form effective communities, reducing the isolation that may have been experienced on campus.

Every spring, during open campus, the Latina student organisation has a café. So everyone brings their prospective student. They usually try to assign you to a Latina if you’re Latina. I was in this room of like 50 people and everyone was talking over each other and everyone was so smart and I just felt like I belonged. And I felt like I was part of a community and part of a family. So that is why I decided to come to this college. Because I felt like, “Oh, look at all these Latinas who are like me” and they were like “I feel so at home here.” The Latina student organization has given me a home and a place to nurture a different part of myself. It is a part of the community that I feel much tied to—And feel involved in and feel like I’m contributing to. So in that sense it adds to my perseverance because I feel like I have something to give back to the community and a reason for staying.

I feel like the Black Women’s House is one of those places where you find your friend groups and then you’re able to kind of talk about the struggle because a lot of people will understand where you’re coming from especially if they’re in the sciences and they understand that struggle of being sometimes the only minority student in the class.

 Brazilians just want to go and dance or go out and play some music or listen to live music and that doesn’t really happen on campus unless you look for it, and that’s one of the reasons why I joined Latino Dance Corner. I was president of that for two years and on the board, my freshman year as secretary. So I was then able to cope because I was able to find people on campus that think the same way in regards to that cultural aspect.

I’m actually part of one of the Latino organisations – It’s for all of the student body that identifies as Latino. I like it. When I feel homesick I go to them.
While participating in diversity focused campus organisations assisted URM female STEM students in finding a cultural home on campus, participating in a culturally based STEM organization created additional avenues for academic engagement and social encouragement. These academic and relational networks affirmed students’ cultural identity as well as their identities as STEM scholars. The National Society of Black Engineers (NSBE) and the Minority Association of Pre-Health Students (MAPS) were among several organisations which multiple students discussed as inspirational and supportive.

One of my theories is that if we had a stronger NSBE chapter, it might help women of color succeed even more. Our mission is to literally increase the number of culturally Black engineers which would be nice—because for me, having that support group helps. It’s nice to know that if I need anything, they’re there. C3

Although participation in an academically and ethnically related STEM campus organization may enhance students’ sense of academic belonging sometime over the course of their university experience, when reflecting on their first year of study, less than half of URM female STEM students (40%) and their non-URM counterparts (46%) indicated a positive response to the prompt “during my first year I felt a sense of belonging in my academic community”, \((U=14740, p=.156, r=.07)\). Within the liberal arts college setting, the majority of students do not declare their major field of study until sometime during their second year of college. In this study, 34% of URM female STEM students formally selected their STEM major during first year, with an additional 50% of students declaring their STEM major during second year. For non-URM female STEM students, the percentages were 32% and 56% respectively. As the majority of students have yet to settle into their academic departments during their first year of college, it is understandable that they may lack a developed attachment to their academic community during that time. Yet, during the second year of study, URM female STEM students who persisted showed marginal progress in their sense of
academic belonging when compared to non-URM female STEM students and the widening gap between these two groups is significant (46% vs. 66%; U=12388, p=.000, r=.18). During the interviews, many URM women spoke of commencing their college studies with a strong sense of academic self-confidence, an attribute that may affect academic belonging (Inzlicht, Good, Levin & vanLaar, 2006). However, as first year progressed into second year, the increasing depth of the subject matter, combined with any pre-college academic deficits, coupled with other internal demands, worked together to produce a dip in students’ academic self-confidence.

I definitely say freshman [1st] year my academic self-confidence was probably like at a high...It was really hard to adjust and then I think after freshman year, then it declined. And then sophomore [2nd] year fall, it declined. And then I think it hit like a negative level during sophomore spring but then I made the climb up during junior [3rd] year. And now, I feel like I'm getting higher so that's a good thing. It's definitely is like a downward spiral now going up. W6

I’d have to say my academic self-confidence has done a full period. Top of a sine curve to the next top... I came in pretty high. And then I hit a low. And then I hit high again. So that’s what’s going on. As far as the lows-- I don’t know if it was just the people and me comparing myself too much or if it was just me, honest to goodness, struggling with the workload and the new concepts being thrown at me that I wasn’t prepared for. W2

I would definitely say that my academic self-confidence immediately entering college was very high...about a semester in was pretty low. Umm it’s definitely increased but not just increased, I think it’s almost like, this is going to sound very poetic but it solidified in that I’m confident that what I’ve been taught I know and that I’ve also been taught what I don’t know, and how to ask about that... But one of the hardest things to accept is you’re no longer the smartest person in the room and you’re probably not the smartest person in about a 1-mile radius. So, what do you do with that? And I think that was something that really kicked me. W1

[My academic self-confidence], it’s been challenged. I wouldn’t say it has diminished... Yeah, definitely hit a low. Sophomore year, I mean [sighs] organic chem is one of these do-or-die classes here... Leaving high school, I mean I excelled. I finished fourth in my class. I was pretty used to doing well and not really having to second guess myself. When I got here, there was definitely a challenge. I wasn’t excelling in science. I mean I was doing good in everything else but science was really giving me a hard time. And I was frustrated at first. I’m not slow. “What’s going on?” H6

Although URM female students who persisted in STEM did not generally indicate experiencing a strong sense of academic belonging during their first two years of college, in the last two years of their STEM studies the vast majority of students
developed strong connections with their advisors/mentors and teachers who acted as necessary agents in the exchange of academic support and may have, through these interchanges, encouraged persistence. Both URM and non-URM female STEM students indicated that their advisor/mentor is a source of academic encouragement and the differences between URM and non-URM female STEM students’ responses to this prompt was non-significant. More than 90% of those interviewed spoke positively about their relationships with their advisors. For many, having more than one point of contact with their advisors, such as also having them as teachers in a class or as supervisors in a laboratory increased the depth of connection and level of trust. Though the main role of an academic advisor is to advise students on academic progress, effective advisors were those who acted as personal mentors to students, demonstrated personal care and encouraged students in issues of both life and career.

*My adviser, I’m very close to. He’s an engineering professor and I had a couple of classes with him but he’s like the best ever, like I love him. We’re so close, I did research with him in the summer, he’s the best person ever, I can go talk to him about school…* W8

*My engineering adviser is just amazing. Oh, she is helpful with everything; I’ve taken classes with her too. She just, always, when I ask for help on homework or about concept, conceptual stuff she helps me. Um, I’ve asked her about internships. W9

*I work with my adviser. She’s working on infections and stuff like that which is what I’m really interested in. I felt like her lab is very open and you feel really included and it’s a very welcoming environment…. so I kind of just looked her up and saw that she was doing infectious diseases and just spoke up and said, “Can you please be my adviser and help me through this?” and she said yes…* W13

*My advisor is definitely like a mentor to me-- she’s awesome that’s why I transferred to her in the first place. I initially had an adviser who is a biology dude, but I just felt like I never could connect to him, maybe because he was a White male professor. Professor K being a woman kind of helps, but at the same time, I guess I wish I had like a woman of color…* W15

*My academic advisor is one of the nicest people I’ve known. She is very intense in the classroom but she is very nice outside. She wants you to explore your own thoughts. And I feel like knowing her as my advisor and also as a professor has kind of like allowed me to appreciate what she does, you know? As my advisor, she always encourages me to aim high.* W17
I’ve done two independent studies, both with Dr. P who is downstairs and she’s my adviser. All of my interactions have always been positive. My relationship with her is great, yeah. W16

Both URM and non-URM students gave even higher marks to their teachers and indicated affirmatively that their teachers provided them with academic encouragement, 83% and 92% respectively. Only 2% of URM female STEM students believed that their teachers were not a source of academic encouragement. Though the median response was identical for both groups of students on whether their teachers were a source of academic encouragement, the mean ranks proved significant (Median=4, $U=13302$, $p=.003$, $r=.14$). Of the 30 interviewed students, only one student spoke of having a difficult time connecting with faculty. URM female STEM students overwhelmingly praised their faculty and credited them as being approachable, accessible, helpful and committed, and also wanting them to succeed, even taking an interest in their careers and future. The smaller liberal arts environment, in particular, also afforded students the opportunity to take multiple classes/subjects with the same professors, further facilitating an even deeper connection both inside and outside the classroom.

I’ve taken now three physics classes with one professor, so I’m really close to her. So that’s nice because the first time I took it with her, she’s wonderful professor but I was very shy. I’m generally bad about going and talking about my struggles with professors. But because I’ve had her so often she already has seen me hit rock bottom in physics world. So, I’m like whatever struggles I have now I can go talk to her. Even this semester like I’ve struggled in a different class that isn’t hers but I’ll talk to her about it. W4

I feel like I have a good relationship with the professors, Cahill being small in liberal arts, you can get that one-on-one, your teachers are going to know who you are. I think that was a really good thing. It helped me remain within STEM because if I had struggles, I could go to them...and so I think faculty being open to communication and just being available for me to go in is very helpful. C2

Every now and then I’ll go and I’ll have lunch with M [a female professor] and we’ll try and catch up and particularly now with graduation—impending. I’m trying to figure my career and life after college. It’s one of those things where I just go to her and [say], “Help.”... In some ways, my professors have been very impactful on my success because they’re the ones who’ve given me the tools to succeed and they’ve given me in some ways, the role models too. W1
Faculty are great. They’re always there to help you especially in engineering…and because students have strong relationships with faculty on campus, faculty are always around. I don’t think there’s ever been a day on this campus where I walked into the Engineering building and didn’t get a hello from a faculty member, or start a conversation with a faculty member, or just have the ability to pull out a piece of paper from my backpack and say, “Do you have a second to explain this to me?” They’re always there. They’re always there to help you, so I think those relationships exist all the time and exist everywhere. Within Engineering, I can definitely say that... Professor P, he is always around to meet with us and sometimes we have dinners and cook stuff from home. Yeah, he is a Brazilian professor, so I’ve been able to find people that are from my country. And it’s nice because you get to keep the language going and they just understand. C5

My biology professor, I could call her at 10 o’clock at night and say, “I need some help. I don’t understand this.” And she will talk to me on the phone until I understood it. She’s just an amazing person that really has helped me out. There are multiple professors that are open like that. H2

For the most part, the faculty are amazing. I’ve gotten to know a lot of them on a more personal level, it’s not just going into their office asking about something that I learned about. They really are here for you and really are curious as to where you come from, what you want to do with your future. And I think they [faculty] have been the biggest influences in my life just because again, they’ve made me question what I want to do with my career because now, you know, you think bio or you think math and you associate it with certain careers, where now I know that there’s so many different options that I can do with my degree, it’s not just one set path. So, I think they’ve been really great and supportive of that. C6

In my department the faculty, they’re really accessible. I’ve also had experiences with the Chem Department and the Biology Department, they’re very accessible. That’s one of the best things that I think my college has, is that the professors would go out of their way to make sure you understand the material and if you don’t understand, they’ll keep trying... They in essence, they just want you to succeed. W17

The professors are amazing. They spend plus hours trying to help. And so, in the things that I’m lacking, I’d have to say that my professors and my friends are really pushing me through... the professor I’m doing research with right now, Dr. S., he’s super helpful and I felt like I could turn to him when it comes to career options or trying to look for extra internships, things like that. W2

Within the classroom setting, several students spoke of different strategies their teachers implemented which they found beneficial towards reducing the social stress of feeling isolated or marginalized in the classroom due to their ethnicity. One particular method that teachers employed that appeared to reduce the social isolation for URM female STEM students within the classroom setting was professors assigning problem-solving groups or lab partners.
One thing that I learned last semester that made me not hate Chemistry was fact that my professor, he would always assign groups for P [problem] sets where you have to work with different people... at first I hated it but then it really did help. At first I was like, “Oh my God, this is so annoying.” But I made so many friends in that class and I got to talk. So he would assign different people each time but sometimes you get the same people again. So I thought that was really helpful because it helped me to talk to people and get to know people that otherwise I would never have talked to, I would never have gotten to know. And it gave me two really good friends who otherwise I probably would’ve never thought to talk to them or never thought to associate with them or anything like that. And I felt that made the class a lot more enjoyable. Whereas you contrast that to all my other experiences, words like “I feel like I’m alone in the class and I feel like I don’t relate to anyone.” And then that just taught me how many times have I been wrong? How many times have I, you know, my next close friend was right beside me but because everyone is so like one woman for themselves and they don’t want to help anyone else or they don’t want to be friends with anyone else. How many times have I missed out on the opportunity to really create a bond. W6

It’s always so uncomfortable picking lab partners... So then you don’t want to like fulfill that stereotype being the Black student who’s not as good but you are good...it is really stressful... I like it when we switch lab partners each week. W7

All those Intro Classes, all the like basics—Yeah, umm, and I think assigning groups that helps with keeping everything even. And when you get to higher level courses, you have more freedom to pick the groups that you’re in. C5

Besides acting as sources of support for URM female STEM students, as these comments illustrate, teachers also facilitated connections between students within the classroom widening their impact in the transfer of social capital. In addition to advisors and teachers, classmates also proved to be an invaluable source of academic support and inspiration to their fellow students. Each of the colleges represented in this study are residential institutions where the great majority of students live within the campus. This type of on-campus residential living experience offers both the environment and the time for students to develop meaningful relationships both in and beyond the classroom. When asked if their classmates were a source of academic encouragement, 74% of URM female STEM students compared to 82% of non-URM female STEM students agreed with that statement. The interview data further reveals that URM female STEM students who persist have highly supportive relationships with their peers in STEM, primarily with other students of colour in STEM, and to a much greater percentage than indicated by the survey responses. For many of the interviewed URM female STEM
students, their fellow minority classmates in STEM were a motivating source of support, helping them to forge smaller, more specific communities within the context of a larger STEM community. In many ways what bonded these students was a common appreciation of the struggle they each faced as students of colour in pursuing and persisting in STEM.

I think for me it’s been great to have them [friends in NSBE] because they understand my struggle or whatever happened. I mean, we all tend to struggle but it’s like—You know, they also have a very similar experience to mine. C3

I do feel more comfortable going to my Latina peer in my physics class, to go to her and be like hey I don’t understand this. I feel more comfortable going to her than to others - - which is weird and I don’t know why. So Spanglish is kind of like our language. W4

My college friends, two of my close best friends, they’re engineering majors as well, and one is Dominican and Puerto Rican, the other one is African-American… they are my biggest support system here at college, they understand, they get the struggle. W8

Coming in with them [other Posse Scholars] was very helpful because although I did have lab groups in which I would be with mainly White students, I also was able to talk to them, “Okay, are you guys struggling with this as well? Okay, so it’s not just me”. I felt as though a lot of the other students didn’t show their struggles or insecurities in the subject, so I felt like, okay. C2

People in my classes, people that I met in freshman year, we just look at each other and say, “Hey, we got to study together. We got to figure out how to pass this class.” Oh yeah, definitely helpful. For sure, if I didn’t have that I don’t know where I would be… noticing first years that were in my classes that struggled as much as I did that are also making it, that are also currently employed. I think all of those things helped me get through. C5

It was just one of the things that you find your friends who are in the same classes as you… to find someone who looks like you or comes at least from the same background as you...Because they can really relate...So, finding people that were in the same struggle … Yes, I was able to find these people. It’s not a lot but you’ll find them. In those office hours, you’ll find them. So, that was really important in building that relationship…W8

During freshman year, we would all joke like, “We all got to stick together,” because I took the biology path starting off. I said, “We all got to stick together.” So everyone in the biology class, we all get these study sessions because it was like we’re all going to make it out of here, we’re going to do it. And so the people that I did that with, they’re still on the track with me even though I went to chemistry and they’re still on the biology side, we’re still on the track together like, “You guys, we got to make it through.”... Bonding helps people stick with it… And I feel like when you do have that support of seeing other people working through it with you, like I said in biology and stuff, I know that it was a group of us that really we would support each other in order to get through because we knew it’s difficult and we knew not a lot of people that look like us are doing it. So the support group was really, really important. H3
Creating a sense of community and solidarity with other students who understood the struggles of being a student of colour in STEM appears paramount to the success of URM women. Yet, beyond simply understanding the struggle they faced, URM female STEM students who persisted had acquired equal levels of college specific cultural capital when compared with their non-URM counterparts. As well, a comparison between URM female students in STEM and non-URM female students indicated that both groups did not show a statistically significant difference in their levels of resiliency to setbacks \((U=16081, p=.877, r=.01)\). Both URM female STEM students and non-URM female STEM students were better prepared to handle setbacks than when in high school. For URM female STEM students, highly significant correlations were produced when their responses to “I am better prepared to handle setbacks than in high school” was correlated to “my classmates are a source of academic encouragement” \((r=.412, p=.000)\) and also correlated to “my teachers are a source of academic encouragement” \((r=.266, p=.005)\). Though resilience may be a trait experienced at an individual level, the supportive foundation upon which it is built appears to be attributed to the collective influence of both classmates and teachers (Benson, Leffert, Scales, & Blyth, 1998).

**Comparisons between URM female STEM students based on attendance at different types of colleges (Coeducational, Women’s, HBCU).** In this next section comparisons are drawn between URM female STEM students based upon the type of liberal arts college attended – coeducational, women’s, or HBCU. A Kruskal-Wallace test was performed to assess the differences in college experiences, college support structures, perceptions of campus environments and resourceful campus relationships for URM female STEM students who attended different types of liberal arts colleges (see Table 13). When assessing the specific indicators of college
experiences for URM female STEM students, statistically significant findings based on college type were not indicated.

Table 13
Comparing College Experiences, College Support Structures, Perceptions of Campus Environments and Resourceful Campus Relationships for URM Female STEM Students at Different Types of Colleges-Kruskal-Wallis Test (N=92)

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<td><strong>College Support Structures</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Received Adequate Financial Aid (n=87) (a)</td>
<td>36.16</td>
<td>48.21</td>
<td>46.78</td>
<td>4.386</td>
<td>.112</td>
</tr>
<tr>
<td>Acquired Cultural Capital Factor</td>
<td>52.40</td>
<td>45.73</td>
<td>39.83</td>
<td>3.203</td>
<td>.202</td>
</tr>
<tr>
<td>Receive academic prep for successful STEM career</td>
<td>55.94</td>
<td>41.89</td>
<td>41.33</td>
<td>8.666</td>
<td>.013*</td>
</tr>
<tr>
<td>Receive career advice for successful STEM path</td>
<td>52.58</td>
<td>41.32</td>
<td>47.70</td>
<td>3.659</td>
<td>.161</td>
</tr>
<tr>
<td>College preparing me well for chosen career path</td>
<td>51.95</td>
<td>45.83</td>
<td>39.43</td>
<td>3.115</td>
<td>.211</td>
</tr>
<tr>
<td>Possess skills to get admin questions answered</td>
<td>46.37</td>
<td>51.93</td>
<td>35.58</td>
<td>5.915</td>
<td>.052</td>
</tr>
<tr>
<td>Know where to go if I need help or falling behind</td>
<td>45.00</td>
<td>47.80</td>
<td>46.15</td>
<td>.238</td>
<td>.508</td>
</tr>
<tr>
<td><strong>Perceptions of Campus Environments</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early STEM Academic Belonging Factor</td>
<td>42.26</td>
<td>43.71</td>
<td>58.80</td>
<td>5.708</td>
<td>.058</td>
</tr>
<tr>
<td>Felt sense of academic belonging in first year</td>
<td>43.27</td>
<td>43.20</td>
<td>58.28</td>
<td>5.391</td>
<td>.068</td>
</tr>
<tr>
<td>Felt sense of academic belonging in second year</td>
<td>42.92</td>
<td>44.70</td>
<td>55.75</td>
<td>3.496</td>
<td>.174</td>
</tr>
<tr>
<td>Campus takes diversity issues seriously/effective programs</td>
<td>41.58</td>
<td>50.20</td>
<td>46.55</td>
<td>2.142</td>
<td>.343</td>
</tr>
<tr>
<td><strong>Resourceful Campus Relationships</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquired Social Capital Factor</td>
<td>54.55</td>
<td>43.32</td>
<td>40.55</td>
<td>4.457</td>
<td>.108</td>
</tr>
<tr>
<td>Advisor/Mentor source of academic encouragement</td>
<td>46.31</td>
<td>43.62</td>
<td>52.70</td>
<td>1.745</td>
<td>.418</td>
</tr>
<tr>
<td>Teachers source of academic encouragement</td>
<td>52.81</td>
<td>43.65</td>
<td>42.58</td>
<td>3.142</td>
<td>.203</td>
</tr>
<tr>
<td>Formed relationships of trust to help me graduate</td>
<td>54.76</td>
<td>41.74</td>
<td>43.45</td>
<td>5.255</td>
<td>.072</td>
</tr>
<tr>
<td>Classmates source of academic encouragement</td>
<td>53.03</td>
<td>43.62</td>
<td>42.28</td>
<td>3.390</td>
<td>.184</td>
</tr>
<tr>
<td>Better prepared to handle setbacks than in HS</td>
<td>51.82</td>
<td>44.32</td>
<td>42.23</td>
<td>2.258</td>
<td>.323</td>
</tr>
<tr>
<td><strong>Multi-Ethnic Identity Measure (MEIM)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEIM Composite</td>
<td>45.10</td>
<td>42.80</td>
<td>53.90</td>
<td>2.428</td>
<td>.297</td>
</tr>
<tr>
<td>MEIM-EI Ethnic Identity Exploration</td>
<td>43.68</td>
<td>44.95</td>
<td>51.63</td>
<td>1.209</td>
<td>.546</td>
</tr>
<tr>
<td>MEIM-EC Ethnic Identity Commitment</td>
<td>46.52</td>
<td>41.32</td>
<td>54.83</td>
<td>3.547</td>
<td>.170</td>
</tr>
<tr>
<td><strong>Science Identity Index Score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEIM Composite</td>
<td>46.83</td>
<td>39.80</td>
<td>55.25</td>
<td>4.809</td>
<td>.090</td>
</tr>
</tbody>
</table>

Note: Two URM respondents’ data were not used for portions of this analysis due to missing data that could not be imputed. a. 87 of 94 URM students indicated that they were financial aid recipients b.Post-Hoc Analysis was undertaken through running a Mann-Whitney U test between each pair of college types for each significant finding. (b)Received academic prep for successful STEM career: Coed> Women’s (p=.005), Coed>HBCU (p=.021) *p<.05; **p<.01; ***p<.001; Effect sizes (ES): small $\eta^2=.01$; medium $\eta^2=.06$; large $\eta^2=.14$

While the total number of extra and co-curricular activities in which URM female STEM students participated was near identical across the three different college types, the types of activities in which students participated outside the classroom differed significantly (see Figure 8). URM female STEM students from coeducational colleges
were more involved in professional clubs (SWE, NSBE, etc.) than were URM female STEM students from either women’s colleges or the HBCU ($\chi^2(2) = 10.180, p = .006, r = .329$). Additionally, URM female STEM students who attended the HBCU volunteered more than did URM female STEM students from either women’s or coeducational colleges ($\chi^2(2) = 8.393, p = .015, r = .299$).

Based on college type attended, URM female STEM students did not differ significantly in measured levels of Acquired Cultural Capital. However, there was a significant difference in one of the Acquired Cultural Capital indicators of receiving the academic preparation for a successful STEM career ($H(2) = 8.666, p = .013$). Post-hoc analysis was undertaken to investigate differences between the college types by performing a Mann-Whitney U test. In order to control for type I error, a Bonferroni correction was applied, resetting the significance level from $p = .05$ to $p = .017 (\alpha/n: .05/3)$ for the post-hoc analysis. This post-hoc analysis revealed that URM female STEM students who attended coeducational colleges indicated a stronger belief that they were receiving the academic preparation for a successful career in STEM when compared to URM female STEM students who attended women’s colleges ($p = .005$). For URM female STEM students across these three college types, there was a significant correlation between participating in a professional club and receiving the academic preparation for a successful STEM career ($r = .327, p = .001$). For URM female STEM students who attended coeducational colleges, 52% were involved in a “professional club” such as the National Society of Black Engineers or the Society of Women Engineers, compared to only 20% of URM female STEM students from women’s colleges. Additionally, URM female STEM students from women’s colleges indicated to a greater extent than URM female STEM students from the other college types, of the resourceful knowledge in possessing the skills to get administrative questions answered,
such as completing internship applications, etc. Although this was a marginally significant result ($p=.052$), it demonstrated a medium effect size.

![Figure 8. Percent participation in extra and co-curricular activities for URM female STEM students by college type.](image)

In assessing the differences between URM female STEM students in their sense of Early STEM Academic Belonging, URM female STEM students from the Hayden University (HBCU) indicated experiencing the strongest levels of a sense of academic belonging during their first two years of university study. Though marginally significant ($p=.058$), a medium effect size of .06 was found. Hayden University also held the highest perception of campus racial climate. For URM female STEM students, Racial Climate was negatively correlated to Early STEM Academic Belonging ($r = -.483$, $p<.001$) indicating that as URM female STEM students’ negative perceptions of Racial Climate increased their sense of belonging in the academic environment of STEM also decreased.
In order to evaluate the differences between URM female STEM students’ perceptions of Racial Climate at each of the three college types, a Fisher’s exact test was applied to the indicators of Racial Climate used in this study. As Table 14 and Figure 9 shows, there is wide variation in the experience of alienation on campus and in STEM classes for URM female STEM students based on the college type attended. URM female STEM students from PWIs indicated they experienced greater levels of isolation in STEM classes than on campus.
Figure 9. URM female STEM students perceptions of alienation on campus and in STEM by percentage and college type (N=92)

However, when comparing URM female STEM students’ experiences of institutional discrimination at the different college types, statistically significant differences based on college type was not found. Likewise, there was a non-significant difference between URM female STEM students and their reports of experiencing aspects of racial discrimination from their teachers based on the type of college attended (see Table 14, see Figure 10). URM female STEM students at coeducational colleges, women’s colleges and HBCU indicated experiencing racial discrimination at an institutional level of 29%, 27% and 25% respectively; students reported experiencing even lower levels of racial discrimination from teachers, 7%, 12% and 5% respectively. Additionally, when comparing students’ perceptions of their campus’ efforts towards issues of diversity and effective programs for diversity, there did not appear to be statistically significant differences between the responses of URM female STEM students who attended either coeducational, women’s or HBCU institutions (see Table 13).
The Impact of Inherited Cultural Capital, Campus Environments and Ethnic Identity on the Acquisition of Cultural Capital during College

Bivariate correlation and multiple regression analyses were conducted to examine the relationship between cultural capital acquired during college and the potential predictors of inherited cultural capital, campus environment, and ethnic identity for URM female STEM students. The first correlation analysis explored the college level variables of campus environment and ethnic identity as predictors for Acquired Cultural Capital. The second correlation analysis focused on the pre-college level variables associated with inherited cultural capital as predictors for cultural capital acquired during college.

In the first correlation analysis Campus Environment predictors were defined as Racial Climate, campus’ diversity efforts/effective programs and Early STEM Academic Belonging. The Multi-Ethnic Identity Measure (MEIM) overall scale and the two subscales of ethnic identity exploration (MEIM-EI) and ethnic identity commitment

![Chart showing perceptions of racial discrimination from teachers and on an institutional level by college type attended (N=92)]

**Figure 10.** URM female STEM students’ perceptions of racial discrimination from teachers and on an institutional level, by college type attended (N=92)
(MEIM-EC) were used as predictor variables for ethnic identity. Table 15 summarises the results of the first correlation analysis. All three predictor variables pertaining to campus environment displayed a significant correlation to the dependent variable of Acquired Cultural Capital. Ethnic identity commitment (MEIM-EC) was the only predictor variable relative to ethnic identity that significantly correlated to the dependent variable of Acquired Cultural Capital. The predictor variables that displayed a statistically significant correlation to the dependent variable of Acquired Cultural Capital were then used in a regression analysis that followed.

Table 15

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus Environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Racial Climate Factor</td>
<td>-.214</td>
<td>.020*</td>
</tr>
<tr>
<td>Campus Diversity Efforts/Programs</td>
<td>.474</td>
<td>.000***</td>
</tr>
<tr>
<td>Early STEM Belonging Factor</td>
<td>.276</td>
<td>.004**</td>
</tr>
<tr>
<td>Ethnic Identity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEIM</td>
<td>.158</td>
<td>.066</td>
</tr>
<tr>
<td>MEIM-EI</td>
<td>.059</td>
<td>.288</td>
</tr>
<tr>
<td>MEIM-EC</td>
<td>.216</td>
<td>.019*</td>
</tr>
</tbody>
</table>

***p<.001; **p<.01; *p<.05

In order to determine if prior levels of inherited cultural capital influenced cultural capital acquired during college, further analysis was undertaken. Consistent with previous research studies, operationalized variables for inherited cultural capital usually include mother’s educational level, father’s educational level, mother’s occupation, father’s occupation and family income (Winkle-Wagner, 2010). For this analysis, and based on work by Perna (2000) and Wells (2008), the variables pertaining to inherited cultural capital were extended to also include educational expectations of high school, sources of help with the college application process, participation in a STEM enrichment program in high school, the academic influence of high school peers,
encouraged to attend college by family, encouraged to attend college by other adults (teachers, counsellors), and parental involvement during high school. Table 16 highlights the results from this bivariate analysis.

Table 16

Correlation Analysis of Acquired Cultural Capital with Pre-College Level Predictor Variables of Inherited Cultural Capital (n=93)

Dependent Variable: Acquired Cultural Capital

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Income</td>
<td>.041</td>
<td>.701</td>
</tr>
<tr>
<td>Mother in STEM Occupation</td>
<td>-.173</td>
<td>.098</td>
</tr>
<tr>
<td>Father in STEM Occupation</td>
<td>-.049</td>
<td>.643</td>
</tr>
<tr>
<td>Mother’s Level of Education</td>
<td>.030</td>
<td>.777</td>
</tr>
<tr>
<td>Father’s Level of Education</td>
<td>.078</td>
<td>.467</td>
</tr>
<tr>
<td>First-generation College Student</td>
<td>-.038</td>
<td>.719</td>
</tr>
<tr>
<td>Education Expectations of HS</td>
<td>-.125</td>
<td>.235</td>
</tr>
<tr>
<td>STEM Enrichment Program in HS</td>
<td>.076</td>
<td>.472</td>
</tr>
<tr>
<td>Peer Academic Influence in HS</td>
<td>.123</td>
<td>.241</td>
</tr>
<tr>
<td>Encourage Attend College-Family</td>
<td>.104</td>
<td>.325</td>
</tr>
<tr>
<td>Encourage Attend College-School</td>
<td>.257</td>
<td>.014 *</td>
</tr>
<tr>
<td>College Application Support from HS</td>
<td>.273</td>
<td>.009 **</td>
</tr>
<tr>
<td>Parental Involvement in HS</td>
<td>.163</td>
<td>.120</td>
</tr>
</tbody>
</table>

\( a: \) school = teachers, school counsellors

*\( p < .05; \) **\( p < .01 \)

The correlation analysis indicated that encouragement to attend college by school personnel, and the number of sources of college application support from their high school or college preparatory program, were the only predictor variables that demonstrated a statistically significant relationship with the dependent variable of Acquired Cultural Capital. There were no other statistically significant correlations linking variables related to familial inherited cultural capital (parents’ education, parents’ occupation and family income) with variables related to cultural capital “learned” during the college years, indicating that for URM female students in this study who persisted in STEM there does not appear to be a direct relationship between those two distinct measures of cultural capital.
Table 17

Multiple Linear Regression Analysis for Predicting Acquired Cultural Capital for Pre-College Variables of Inherited Cultural Capital and College-Level Variables of Campus Environment and Ethnic Identity (n=93)

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>B</th>
<th>B(SE)</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL 1 (R² =.419)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>1.586</td>
<td>.418</td>
<td>3.798</td>
<td>.000***</td>
<td></td>
</tr>
<tr>
<td>Racial Climate Factor</td>
<td>-.088</td>
<td>.062</td>
<td>-.143</td>
<td>-1.413</td>
<td>.161</td>
</tr>
<tr>
<td>Campus Diversity Efforts/Programs</td>
<td>.236</td>
<td>.062</td>
<td>.336</td>
<td>3.830</td>
<td>.000***</td>
</tr>
<tr>
<td>Early STEM Belonging Factor</td>
<td>.115</td>
<td>.065</td>
<td>.172</td>
<td>1.787</td>
<td>.077</td>
</tr>
<tr>
<td>MEIM-EC</td>
<td>.205</td>
<td>.067</td>
<td>.274</td>
<td>3.071</td>
<td>.003**</td>
</tr>
<tr>
<td>Encour Attend College-Other Adults</td>
<td>.228</td>
<td>.082</td>
<td>.261</td>
<td>2.77</td>
<td>.007**</td>
</tr>
<tr>
<td>College App Support</td>
<td>.043</td>
<td>.029</td>
<td>.140</td>
<td>1.489</td>
<td>.140</td>
</tr>
<tr>
<td>MODEL 2 (R² =.406)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>1.299</td>
<td>.367</td>
<td>3.540</td>
<td>.001**</td>
<td></td>
</tr>
<tr>
<td>Campus Diversity Efforts/Programs</td>
<td>.254</td>
<td>.061</td>
<td>.362</td>
<td>4.184</td>
<td>.000***</td>
</tr>
<tr>
<td>Early STEM Belonging Factor</td>
<td>.156</td>
<td>.058</td>
<td>.232</td>
<td>2.673</td>
<td>.009**</td>
</tr>
<tr>
<td>MEIM-EC</td>
<td>.178</td>
<td>.064</td>
<td>.237</td>
<td>2.764</td>
<td>.007**</td>
</tr>
<tr>
<td>Encour Attend College-Other Adults</td>
<td>.236</td>
<td>.082</td>
<td>.270</td>
<td>2.862</td>
<td>.005**</td>
</tr>
<tr>
<td>College App Support</td>
<td>.037</td>
<td>.029</td>
<td>.120</td>
<td>1.286</td>
<td>.202</td>
</tr>
<tr>
<td>MODEL 3 (R² =.395)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Constant)</td>
<td>1.242</td>
<td>.366</td>
<td>3.396</td>
<td>.001**</td>
<td></td>
</tr>
<tr>
<td>Campus Diversity Efforts/Programs</td>
<td>.257</td>
<td>.061</td>
<td>.366</td>
<td>4.220</td>
<td>.000***</td>
</tr>
<tr>
<td>Early STEM Belonging Factor</td>
<td>.159</td>
<td>.058</td>
<td>.236</td>
<td>2.719</td>
<td>.008**</td>
</tr>
<tr>
<td>MEIM-EC</td>
<td>.197</td>
<td>.063</td>
<td>.263</td>
<td>3.137</td>
<td>.002**</td>
</tr>
<tr>
<td>Encour Attend College-Other Adults</td>
<td>.283</td>
<td>.074</td>
<td>.324</td>
<td>3.820</td>
<td>.000***</td>
</tr>
</tbody>
</table>

a: other adults = teachers, school counselors

***p<.001; **p<.01; *p<.05

A multiple regression analysis using the backwards method was carried out to determine the degree to which Acquired Cultural Capital was dependent upon those predictor variables which produced a significant correlation (p <.05): Racial Climate, campus’ diversity efforts/programs, Early STEM Academic Belonging, Ethnic Identity Commitment, encouragement by others to attend college and college application support for URM female STEM students. This regression analysis produced three significant models. A summary can be found in Table 17. Model 3 contained four of the six predictor variables. The model was statistically significant, F (4, 89) =14.525, p<.001 and accounted for approximately 40% of the variance in measures of Acquired Cultural Capital (R²=.395) for URM female STEM students. In Model 3, campus’ diversity efforts/programs, Ethnic Identity Commitment, Early STEM Academic
Belonging, and encouraged to attend college by adults other than family (teachers/counsellors) were statistically significant with campus’ diversity efforts/programs displaying the highest beta value ($\beta=.366, p=.000$) of the statistically significant predictors.

In this regression model, a college’s diversity efforts/programs was the leading indicator that predicted a URM female STEM student’s measure of Acquired Cultural Capital. The majority of students interviewed indicated a belief that their college was not only diligent and proactive in addressing issues of diversity and offered effective programs, but also achieved a notable level of success in this area which in turn translated to a safe, nurturing and empowering environment in which URM students lived, studied and persisted.

*The one thing that my college has done really well at is to help me get to this point... I think it’s created a sort of sense of family and community, where groups have arisen that are very nurturing. So because my college is this general sense of siblinghood and community, then the Latina Campus Group is really, really powerful. So whenever I go into a meeting, I feel really empowered even though we don’t share exactly the same ethnic history but it’s sort of this sense of, you know, we can do this. And especially when we talk about—and seeing alumnae who have gone through the same thing and identifying the same way is also really empowering. W5*

*When I got here I thought that I knew what diversity was and that my college didn’t look like where I came from so it’d be very uncomfortable. And to be completely honest, I learned about all new aspects of diversity once I got here. W3*

*I think one of the positive things about the school culture here is that, like last night there was a senior ladies dinner for women of color, and so they [my college] do I think a lot to help make sure that you feel very welcome and you feel comfortable and that you feel like you can do whatever you want and that there is nothing holding you back. C1*

The regression model also indicated that for URM female STEM students, Ethnic Identity Commitment was a statistically significant predictor for Acquiring Cultural Capital during college. For many of the interviewed students, a commitment to their ethnic identity and their ethnic community has fuelled a desire to persevere, a desire to press on and to learn the skills and acquire the knowledge so that others, particularly those from the same background, can benefit from their experience.
My African American heritage inspires me to keep going and keep pushing. So that I can be an inspiration for other young kids... I feel like those struggles of “Oh, I'm the only Black girl in my lab. I'm the only Black girl in my classes.” Even though those times definitely feel alienating at times, I felt like I’d do it because like “Okay, I’m going to make it so other girls can.”

I mean, the fact that with my [African-American] family has been educated and has been scientists for so long has really inspired me. It’s something I want to keep alive.

I think what inspires me is just the fact that there are so little [women] especially in Geology, women in general are very underrepresented and now Latina women are even less represented. ... I mostly go towards the fields that have less women because I just want to break the barriers. I think that’s one of the things that I want to do.

So, it’s really important to me to show to pave the way for people from back home. I have seven nieces and nephews. I want to show them that there’s more than what you see on TV, you don’t have to be a rapper. You don’t have to be a singer... So, that’s definitely a motivation, me going to school and doing a STEM field... it always been like, okay this is what I wanted but I also got to think about I’m carrying the weight for my family.

So I'm kind of striving to show people that people like me can make it, where I'm at right now.

I feel sometimes—I—if I ever quit engineering I’m like letting down like me and my family and like Black people everywhere because—Graduating, you know, It’s like we’ve come so far and I know it took a lot for me to even be able to go college, let alone being a science major.

I think just being the only Black person in the senior, junior and sophomore class of civil engineers pushes me to make sure I graduate and set an example that a person of color and a female of color especially can do this.

This regression model indicated that cultural capital acquired during college is dependent upon URM female STEM students’ positive assessments of their college’s efforts and campus programs towards diversity as well as their own level of commitment to their ethnic identity.

Science Identity and the College Environment

Considering the domains of performance, competence and recognition as outlined in Carlone and Johnson’s (2007) model of Science Identity for women of colour, and further explored in this study, a Science Identity index score was
constructed using a student’s college GPA, her mathematics self-concept score from the 
SDQ III (Marsh & O’Neill, 1984; Marsh, 1992) and her indication on a 5-item Likert-
type scale if others (classmates/teachers) recognised her as talented in science.

Bivariate correlation and multiple regression analyses were conducted to examine the 
relationship between the dependent variable of Science Identity and the potential 
predictors of campus environment, Acquired Cultural Capital, and Acquired Social 
Capital for URM female STEM students. Campus environment predictors were defined 
as Racial Climate, campus’ diversity efforts/programs and Early STEM Academic 
Belonging. Table 18 summarises the results of the correlation analysis. The predictor 
variables that displayed a statistically significant correlation ($p<.05$) to the dependent 
variable of science identity were then used in a regression analysis.

Table 18

<table>
<thead>
<tr>
<th>Predictor Variable</th>
<th>$r$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Racial Climate Factor</td>
<td>-.439</td>
<td>.000***</td>
</tr>
<tr>
<td>Early STEM Academic Belonging</td>
<td>.401</td>
<td>.000***</td>
</tr>
<tr>
<td>Campus Diversity Efforts/Programs</td>
<td>.075</td>
<td>.483</td>
</tr>
<tr>
<td>Acquired Cultural Capital</td>
<td>.285</td>
<td>.003***</td>
</tr>
<tr>
<td>Acquired Social Capital</td>
<td>.394</td>
<td>.000***</td>
</tr>
</tbody>
</table>

A multiple regression analysis using the backwards method was carried out to 
determine the degree to which Science Identity was dependent upon Racial Climate, 
Early STEM Academic Belonging, Acquired Cultural Capital and Acquired Social 
Capital. This regression analysis produced two significant models. A summary can be 
found in Table 19. Model 2 contained three predictor variables. The model was 
statistically significant, $F (3,88) = 13.135$, $p<.001$ and accounted for approximately 31%
of the variance in measures of Science Identity ($R^2 = .309$) for URM female STEM students. In Model 2, Racial Climate, Acquired Social Capital and Early STEM Academic Belonging were statistically significant with Acquired Social Capital displaying a higher beta value ($\beta = .277$, $p = .005$) than Racial Climate ($\beta = -.254$, $p = .016$) or Early STEM Academic Belonging ($\beta = .221$, $p = .032$).

Table 19

*Multiple Linear Regression for Predicting Science Identity in URM Female STEM Students for College-Level Variables of Racial Climate, Early STEM Academic Belonging, and Measures of Acquired Cultural and Social Capital (n=91)*

<table>
<thead>
<tr>
<th>Predictor Variables</th>
<th>B</th>
<th>B(SE)</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL 1 (Adjusted $R^2 = .310$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>F(4,87)=9.772, $p=.000^{***}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-4.553</td>
<td>1.94</td>
<td>-2.347</td>
<td>.021*</td>
<td></td>
</tr>
<tr>
<td>Racial Climate</td>
<td>-.584</td>
<td>.239</td>
<td>-.254</td>
<td>-2.444</td>
<td>.017*</td>
</tr>
<tr>
<td>Acquired Social Capital</td>
<td>.961</td>
<td>.396</td>
<td>.261</td>
<td>2.426</td>
<td>.017*</td>
</tr>
<tr>
<td>Early STEM Academic Belonging</td>
<td>.539</td>
<td>.260</td>
<td>.215</td>
<td>2.071</td>
<td>.041*</td>
</tr>
<tr>
<td>Acquired Cultural Capital</td>
<td>.121</td>
<td>.402</td>
<td>.032</td>
<td>.301</td>
<td>.764</td>
</tr>
<tr>
<td>MODEL 2 (Adjusted $R^2 = .309$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F(3,88)=13.135, $p=.000^{***}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-4.383</td>
<td>1.847</td>
<td>-2.374</td>
<td>.020*</td>
<td></td>
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<tr>
<td>Racial Climate</td>
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<td>-2.452</td>
<td>.016*</td>
</tr>
<tr>
<td>Acquired Social Capital</td>
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<td>.341</td>
<td>.277</td>
<td>2.990</td>
<td>.004***</td>
</tr>
<tr>
<td>Early STEM Belonging Factor</td>
<td>.554</td>
<td>.255</td>
<td>.221</td>
<td>2.175</td>
<td>.032*</td>
</tr>
</tbody>
</table>

Durbin-Watson = 1.412

In this regression model, Acquired Social Capital was the leading indicator that predicted a URM female STEM student’s Science Identity index score. The Acquired Social Capital factor comprised items related to a student’s belief that her teachers, classmates, advisors/mentors were sources of academic support and that she has formed relationships of trust that will help her graduate, as well as her perceptions that she is better prepared to handle setbacks than when she was in high school.

Several women articulated the importance that role models had in helping them forge their own science identities as future STEM professionals. For some women, these role models were people in their lives with whom they bonded and desired to emulate,
for others it was a person of colour who had found success as an influential individual within the realm of STEM. These inspirational models offered a form of relational capital in which an URM female STEM student could draw upon and then project a vision of her future self in STEM further enhancing her own sense of science identity.

*I definitely look up to my research professor. I want to like be her when I grow up. She’s amazing. Uh, she’s really great. I think a lot of people here, just being able to see friends here who are now gone and they [were] accepted into grad school and medical school, which definitely motivates me all the time. I’m like, if they can do it, I can do it. C6

*When I came here freshman year, she was my lead ambassador mentor and she’s been with me all the way since she graduated last year and she’s actually at medical school right now. So she’s like my inspiration. I was like okay, if you can get in, I know I can get in. H5

*He’s [Latino math professor at W college]been inspirational. Just how much he’s worked and how he’s tried to not let the “I’m the only Latino in this classroom” get to him, which is very much what I feel as well because we are struggling together. W4

*I want to be the next Neil deGrasse Tyson. I love what he’s doing. So Neil deGrasse Tyson is the director of Hayden Planetarium. He’s this Black Astrophysicist... He’s from New York City and he is currently the host of Cosmos and he’s amazing. He’s super, super smart but he’s also really charismatic. So his kind of thing is public education. He was the spokesperson for NASA for many years and I want to do that. W5

When asked about their career or educational plans after college, all 30 of the URM female STEM students who were interviewed indicated that they would be pursuing STEM related plans either directly after graduation or after a gap experience. For these women, the most common plan was post-graduate study (M.Sc. or Ph.D.) with 13 of the 30 students indicating that option. Ten students were planning on attending medical school or dental school, including all seven of the interviewed students who attended Hayden (HBCU). Four students planned to enter the workforce as engineers, two planned on becoming mathematics or science teachers and one indicated that she was planning on starting in a research position after graduation.

One of the domains nested within the model of Science Identity for women of colour in STEM is the recognition component, a perception that others acknowledge
you as someone talented in science (Carlone & Johnson, 2007). For many of the interviewed URM female STEM students, they perceived that others affirmed their capabilities within the sciences. Yet these women felt that the credit they received was mostly deserved because of their hard work and dedication, not necessarily because they possessed an innate giftedness in STEM.

Yeah, definitely, others recognize me as someone who is good at science…I try very hard, I get great grades, I don’t ever hand in anything that’s poorly done you know, I take pride in my work. W11

I guess you could say that others see me as someone talented in science. I don’t really think about it. I don’t really think about it but I can definitely say I think that the view that my peers have of me is that I’m not a bottom performer. I may not always get the best grades, but I’m usually someone who knows what’s going on. H6

I think that’s important that others recognize me as a talented person in science. Because, at the end of the day I feel like people are successful because other people recognize [them as] being successful. W8

I have been very out there in pursuing my science...so I took a research class and she [the teacher] knew my ability and she was like, “You know what, you guys did so good,” – it was only four of us [in the class] – “You guys did so good, I’m going to take this[students’ study guides] and use it for biochemistry, what we did...You can be TAs for the lab or whatever because I know how well you all did”. We’ll have [research class at] 8 am in the morning and be there until 7 at night, almost every day in the lab. So I feel like a lot of people have recognized [me], and I was appointed as an Marc scholar because she recognized that I was being very diligent and successful in pursuing science. H3

I think I am recognized by others... A lot of the first years are like, “Oh, you’re so smart.” And I’m like, “I guess, like my grades are and I’m easy but they’re like pretty good, I guess.” W5

Well, when I’m talking science, yes I feel my friends affirm my talent in science. If we’re having a conversation and they don’t know why things are and I’m like, “Oh, well it’s because of this.” So when I’m talking to them about what I learned and they’re just like, “Okay, it’s all over my head.” W6

For some women this recognition was also a source of pride confirming that others held them in high esteem for pursuing STEM. Additionally, some women enjoyed the social benefit and symbolic capital derived from how others perceived the requisite intellect and level of academic demand required from those who pursued STEM majors in college.
The engineering title kind of pushed me a lot of times too because it sounds great. Chemical engineer. I mean, it just sounds wonderful. So that pushed me but it also gave me pressures.

Every time I say chemistry, everyone’s like, “Oh, that’s hard. Okay.” Others said, “Oh, you’re majoring in science. Oh okay, you’re smart.” That’s the response I usually get. It makes me feel all right. It makes me feel good…

Most of my friends are just like, “Girl, you are crazy.” [Laughter] “I cannot believe you are majoring in chemistry. It’s probably so hard.”

They’re like that is so hard. I can’t believe you’re doing that -- there are guys who don’t sleep, engineering is crazy, that’s what everyone thought, engineering is crazy. I have the heart for it so…Most of them, I’ve got to say, I feel they’re proud of me.

I think a lot of people who aren’t into STEM think, they don’t really think too much about it. They’re just like, “Oh, you do that? You must be really smart.” That’s the response that I get a lot, you must be really smart.

I guess it’s something a lot of female STEM majors like to brag about.

Whenever I say, “Oh, I’m an Astrophysics major.” They’re like, “Wow, you’re really smart.” I like how it makes me feel.

The Effects of Influential Relationships on Persistence

While the vast majority of female STEM students in this study resided on campus and away from their homes, they still received substantial levels of support from their families. Significant correlations existed for URM female students in STEM when comparisons were made between parents are a source of academic encouragement with the variables of mother’s education level \( (r=.281, p=.007) \), father’s education level \( (r=.261, p=.004) \) and family income \( (r=.228, p=.013) \) indicating that there may be some positive connection between the levels of academic support a URM female STEM student in this study received based upon her parents’ prior level of education as well as her family’s SES. While a greater percentage of non-URM female STEM students cited receiving academic support from their parents than URM female STEM students, 87% versus 79% respectively, this result was non-significant when a comparison between
these two groups was drawn through executing a Mann-Whitney U test \((U=14976, p=.225, r=.123)\). URM female STEM students were generous in their praise of the support they received from their families. The interviews revealed that mothers, in particular, played a dominant role in providing the support their daughters needed to press on and persevere. Many URM female STEM students communicated with their mothers regularly, some even daily.

I think my success at college is attributable to a variety of things. One is my mom--she really has taught me to just stick with it...my mom has taught me though that you need to get up and do what you have to do. ...my mom is very strong... she’s very involved in my education. W13

And my mom, that’s my support...My mom just listens to me whine and complain about things. I talk with her every day. H2

Well, my mother is extremely involved in my education. I don’t talk to my father like that, but my mother’s extremely involved... But because I am away, she can’t really come to stuff. But I do talk to her a lot and because I am away, they try to stay really connected with me. H3

My mom is my biggest fan, my biggest cheerleader. She’s helped me through a lot... But my mom really pushes me because she’s like “no, you’re not quitting”. H4

Some days like one phone call...Now, you learn that phone call back home, that’s all you needed. Having that upbringing that strength from my mom is like, “You can do it”... Anything I needed from my mom or help, almost anything she was there.... there’s always support. W8

On those days when I have hit the wall, the first one I go to is probably my mother because she’s always the one who could be counted on to read the situation and give me comfort and console me if I need it. And be like “You’re being stupid, stop. You can figure this out, I know you can.” W1

Though many of the URM female STEM students attributed positive levels of academic support from their parents, the interviews revealed that the type of support received was indeed more emotional than academic in nature. In particular, first-generation URM female STEM students appear even less supported by their parents when compared with URM female STEM students whose parents had completed college (69% vs. 83%; \(U=534.5, p=.003, r=.314\)). Of the 30 URM female STEM
students who were interviewed, ten were first-generation college students. When asked to discuss the types of support they received from their parents, nine out of ten (90%) first-generation URM female STEM students shared how their parents sometimes just don’t comprehend what they are going through to effectively offer supportive encouragement. In some cases, their parents simply don’t understand due to their lack of first-hand knowledge of the college experience.

My family is not always the first people I go to just because it would require several minutes if not hours of explanation... I don’t think they actually understand the scope of everything, which is why they’re not so encouraging. C5

My career plans, yeah my parents, I don’t know, they have never really been that involved you know, a little, “Talk to me about it.” I just don’t think that they understand what it’s like... Because they never went through it. W11

I think the only recognition that I still don’t have is my parents’. So that’s one of the things that I get really upset about... Because they just don’t understand. W17

I remember having a conversation with my mom, trying to explain to her something... she basically ended it saying like, "You think you’re so much better than me because I sent you off to school" blah, blah, blah. W15

Even though the parents of first-generation URM female STEM students lacked the resources to effectively encourage their daughters in academic discussions, others voices of support filled that gap. Over 40% of first-generation URM female STEM students indicated that they had a “professional mentor” compared to 15% of URM female STEM students whose parents had completed college ($\chi^2 (1) = 7.392, p=.007, \eta^2 = .280$). For URM female STEM students, having a professional mentor was significantly correlated to the prompt: I have formed relationships of mutual trust with teachers/advisors that will help me to complete college successfully ($r=.310, p=.003$). Of the 30 interviewed students, 22 students felt that they had someone in their life who for them qualified as a mentor, although it was hard to distinguish the exact designation of who in particular may have qualified as a professional mentor. The lack of a specific definition of this term in both the survey and the interview allowed for students’
individual interpretation. Several students believed that they benefitted from having more than one mentor in their lives. For students who indicated that they had a mentor, the most common mentoring relationship identified was a relationship with a professor (10 of 30). This was followed by mentors from college-prep/scholarship programs (4 of 30), formalized peer mentoring programs (3 of 30), summer internship programs (2 of 30), current post-graduate medical students (2 of 30), high school teachers (2 of 30), volunteer supervisor (1 of 30), and family friend (1 of 30).

And I still go back to my old high school, yes I do have one [a mentor], my old high school, my favourite math teacher, who I did an internship with this past J-term. I was teaching math in his classroom. I just asked him, what do you think was next or his advice for some things. He was like, well, you keep doing what you’re doing. And he keeps encouraging me and he’s all for supporting me… And he’s like whatever you need just come back to me. W9

I am still in contact with him [college-prep program mentor/advisor] because basically, his thing is people of colour in Science. So he is very much, “These are the things you can achieve and if you like it and if you want to do this, this is what you have to do.” W5

And then during freshman [first] year when I was doing biology, we also got partnered with a graduate student at the local medical school and they were like our little mentor. We had socials with them and we would be able to contact them whenever. H3

I don’t have one specific person. I have a few people. Well, one is Ms. J. She works at the Boys’ and Girls’ Club. I volunteered there for two years. We just talked and we went out a few times. She just like encouraged me to keep going, keep going through and if I had any problems, I could talk to her about just anything actually. So I found her as being a mentor to me throughout those two years. H7

Well, I always knew I wanted a school that was an all-women’s college because I had a family friend, like a mentor. She’s really been the guide for me in college and everything else I do. She went to Spelman [all female HBCU] and then she went to Harvard for her MBA and…she is my mentor… she just grew up and really overcame the struggle from being from a rough area and really making her life work…. she’s still my mentor…yeah, so, she is a big help because one day, I just want to be like her. W8

I see the Peer Mentoring Program as very positive because if you’re a mentee and I’m the mentor, you get to kind of look at like what you will be like in like a couple of years. And its’ really scary to see, you know. You’re a first year and you don’t even know where your place is. But if you actually see other people who are kind of like you [and] also made it here, then it kind of encourages you also. So I was a mentee and I was a mentor. My experiences have been positive. I know that as a mentee I didn’t really appreciate its value until I became a mentor. W17
Basically, she [my mentor] has been a major influence in my Biology career. My relationship with her has always felt like a very equal one. There were some certain circumstances conducting the research this summer where she actually ended up being in Germany for almost the entire time, so it was myself and my lab partner. We’re essentially running the lab and working without her guidance there. And she, in essence, basically put all of her trust in us that we were not going to break her expensive machines or mess up with data or do any of that. So when we were conversing, it was very much less firm like a PI to a student worker as two scientists working together. And that I think was really nice because it gave me more of a taste of how it will actually be to work in the laboratory conducting your own research.

For some students mentoring involved a relationship with others in order to increase skills specific to their STEM disciplines. And for other students, mentoring was centred upon positive role model relationships that encouraged persistence in STEM and offered clear direction on how to move forward towards a future path in STEM. Most of these mentoring relationships extended over a period of time, and in many ways students in this study perceived a mentor as someone with whom they could identify and who cared for them, someone who invested in them and offered career and life advice based on their own personal journey.

**Summary**

In this chapter, the quantitative and qualitative results were presented in the context of the five guiding research questions. The summary presented in this next section highlights the key findings as they relate to the research questions and theoretical underpinnings of this study.

When exploring pre-college background and aspects of cultural capital inherited from families, URM female STEM students in this study came from homes where their parents were less educated, earned less income, and were less likely to be engaged in STEM related occupations when compared to their non-URM counterparts. URM female STEM students were almost three times more likely than non-URM female
STEM students to be the first in their family to attend university. URM female STEM students presented with notable deficits in inherited cultural capital when measured by parents’ education, parents’ income level and parents’ occupational status and compared to their non-URM counterparts. However, when cultural capital measured at the pre-college level was extended to capital acquired through the institutional agency of schools, there exists less differentiation between URM and non-URM female STEM students. Both URM and non-URM female STEM students received near equal levels of encouragement from families, teachers and counsellors to attend college. URM female STEM students received significantly greater levels of support outside their families in preparing for SAT/ACT college entrance exams and also in preparing financial aid applications for college when compared to non-URM female STEM students. More than half of the URM female STEM students interviewed in this study participated in a college preparation program during high school and many still maintained strong ties to those programs. Although URM female STEM students appeared to be overall less academically prepared than their non-URM counterparts, these two groups completed AP calculus at similar rates. For URM female STEM students who felt prepared for the academic demands of a STEM major in college, completion of AP STEM courses was the most cited reason.

Interestingly though, 30% of both URM and non-URM female STEM student attended private high schools, triple the U.S. national average of attendance at a private high school. However, when looking at the demographic breakdown of the minority enrolment of the schools attended by this study’s participants, the majority of URM female STEM students attended high schools whose enrolments were more than 50% minority, whereas the majority of non-URM female STEM students attended principally White high schools.
Parents from both student groups exhibited similar levels of academic aspirations for their daughters. For URM and non-URM female students who have persisted in their STEM degree programs at university, there appears to be little difference in the college-going disposition or habitus reflected within their parents. Additionally, of the interviewed women, a significant majority had decided during or before high school that they would pursue a STEM major in college. Of all female STEM students surveyed (N=447), both URM and non-URM, only 4% switched into a STEM major after first declaring a non-STEM major in college.

For many URM female STEM students, their financial aid package was a determining factor in their college choice and for some this decision was confirmed after guidance from non-parental adults in their lives. Overall, URM female STEM students were significantly more satisfied with their financial aid packages than their non-URM counterparts.

Although the URM female STEM students in this study are women who have persisted in their degree program, they were almost twice as likely to consider quitting college and quitting STEM at some point during their college experience when compared with their non-URM counterparts, and this was most significantly correlated to perceptions of STEM competitiveness. For this particular measure of perseverance, there was not a statistically significant difference between URM female STEM students based on whether they attended an HBCU or a PWI (coeducational/women’s).

URM female STEM students perceived the STEM environment as more competitive than did non-URM female STEM students, and they also reported earning lower GPAs. For URM female STEM students, the lower grades earned in STEM were a source of discouragement. However, in order to persist, URM female STEM students redefined certain aspects of their understanding of academic success independent of the
grades they earned. This re-shifting of perspective, which appears necessary for persistence, was often the result of receiving words of affirmation and encouragement within a trusted relationship with a professor or mentor.

In general, URM female STEM students who persisted were more involved in activities outside the classroom than non-URM female STEM students. The majorities of both URM female STEM and non-URM female STEM students have participated in research experiences, have completed an internship and have sought academic help outside the classroom. URM female STEM students who have persisted have participated more significantly than non-URM female STEM students in attending diversity clubs and events, volunteering and in having a relationship with a professional mentor.

When compared to their non-URM counterparts, many URM female STEM students entered their college years with lower levels of family related cultural capital when assessed though the lens of parents’ educational levels, parents’ occupation and family income. However, both URM and non-URM female STEM students who have persisted past their second year in their STEM degree program appear to possess near equal levels of cultural capital as assessed during the college years when measured in the context of the skills and outcomes of receiving the preparation for a successful STEM career, of receiving career advice for a successful STEM path, of possessing the skills to navigate the administrative requirements of progressing through college and of knowing the resources and how to access those resources in order to achieve academic success. In particular, URM female STEM students who persisted have reported receiving career advice for a successful career in STEM to a greater extent than did non-URM female STEM students. Although URM and non-URM female STEM students differed in their levels of inherited cultural capital upon entering college, for students
from both groups who have persisted, any gaps in assessing cultural capital indicators measured during college is non-existent.

The greatest measured statistical differences between URM and non-URM female STEM students can be found in their perceptions of campus racial climate as measured by the Racial Climate factor. While the majority of URM female STEM students have either a neutral or positive perception towards the racial climate on campus, some students recall explicit experiences of lowered expectations from faculty as well as micro-aggressions in some of their interactions with non-URM students. However, as a way to buffer these experiences, URM female STEM students developed supportive networks through involvement in cultural societies and ethnically based STEM organisations.

In the first year of study, URM and non-URM female STEM students’ sense of academic belonging did not differ significantly. However, the gap in STEM academic belonging widened significantly between these two student groups during their second year of study. URM female STEM students who persisted into their third and fourth year of study though, developed deep and meaningful relationships with their peers, faculty, advisors and mentors as well as formed smaller communities with URM peers bonding over their struggle as students of colour in STEM.

While both URM and non-URM female STEM students exhibited positive indicators for measures for social capital acquired during college, significant differences within that positive spectrum existed between the two comparison groups. URM female STEM students formed relationships of trust with teachers, mentors and advisors, and multiple points of contact with these institutional agents, such as having them as teachers and advisors and laboratory supervisors, increased the level of trust and depth of connection, which proved important for persistence. Additionally, many URM
female STEM students formed smaller communities with other URM STEM students within the context of the larger STEM student body. The driving force within these smaller URM STEM enclaves was a common appreciation of the struggle they each faced as women of colour in pursuing and persisting in STEM. The solidarity created within these communities forged a powerful bond which empowered many URM female STEM students towards persistence.

Comparisons drawn between URM female STEM students based on what type of college they attended provided further insight into how the lived experiences of URM female STEM students were shaped at the different types of colleges examined in his study. With the exception of Racial Climate, there were few statistically significant differences between URM female students who persisted in STEM based on which type of college they attended when comparing college experiences, college support structures and resourceful campus relationships; though a few of the comparisons did yield a medium effect size.

URM female STEM students at Hayden (HBCU) held the strongest sense of academic belonging in STEM, most notably in their first year of study. URM female STEM students from Hayden also participated at a significantly higher rate than the other URM female STEM students in volunteering. Also displaying a medium effect size, URM female STEM students from women’s colleges were most satisfied with their financial aid when compared to URM female STEM students at the other types of colleges. Additionally, URM female STEM students from women’s colleges were more self-aware of possessing the skills to get administrative questions answered when compared to URM female STEM students at the other types of colleges. URM female STEM students from coeducational colleges indicated, with a medium effect size, that they were receiving the academic preparation for a successful career and had formed
relationships of trust that would help them to successfully graduate. URM female STEM students from these coeducational colleges also had a high participation rate in professional clubs and organisations, and some causal link is indicated.

Perceptions of campus racial climate yielded the most significant difference between URM female STEM students based on type of college attended. URM female STEM students who attended Hayden were significantly less likely to indicate alienation on campus and in STEM due to their ethnicity. However, responses related to experiencing racial discrimination from teachers or experiencing discrimination on an institutional level did not differ significantly for URM female STEM students based on attendance at an HBCU or PWI (women’s and coeducational).

As explored through a regression analysis, the most significant college-level predictors for URM female STEM students’ measures of Acquired Cultural Capital were students’ perceptions of their campuses’ diversity efforts and effective diversity programs, their sense of belonging in their academic community during their first two years of college, as well as their ethnic identity commitment as measured by the MEIM.

For many of the URM female STEM students interviewed, a commitment to their ethnic identity and their ethnic community fuelled a desire to persevere, with the altruistic hope of one day reinvesting back into their communities. At the pre-college level, the encouragement to attend college by adults other than family members (teachers, school counsellors, other school personnel) also predicted cultural capital acquired during college for URM female STEM students. However, familial indicators of cultural capital such as parents’ level of education, parents’ occupation and family income were not predictors of STEM related cultural capital acquired during college for URM female STEM students.
A regression analysis determined that Racial Climate, Acquired Social Capital and Early STEM Academic Belonging were predictors for Science Identity for the URM female STEM students in this study. The qualitative data further supports these findings as several of the interviewed students articulated the importance of the relationships they have developed with peers and role models in helping them form their own identities as future STEM professionals.

Although most of the URM female STEM students in this study resided away from their home communities while pursuing their higher education degrees, they still received substantial levels of support from their families. Mothers in particular appear most influential in providing emotional support to their daughters. There appears to be a significant positive correlation between parents being a source of academic support and parents’ educational level. URM female STEM students who were the first in their families to attend college appeared less supported by their parents and several of the students attributed this to their parents’ lack of first-hand knowledge of the college experience. However, of these first-generation URM female STEM students who have persisted in STEM, over 40% indicated they had a professional mentor in their lives. Most of the URM female STEM students interviewed in this study indicated they had a relationship with a mentor, a person who intentionally invested in them and offered tailored advice on moving forward in the STEM pathway.

When drawing comparisons between URM female STEM students based on type of college attended (coeducational, women’s or HBCU), the sample size in each sub-group is small. Therefore, caution should be exercised when interpreting results. Although sample size requirements for each of the statistical tests undertaken were met, interpreting results should be limited to the participating students and not generalised to all URM female STEM students who attend these types of colleges.
While the findings of this study have been summarized in this section, the results of this study are further explored in the next chapter in which a more contextualized discussion is offered situating the current findings within the theoretical frameworks chosen for this study, the proposed conceptual model derived for this study, as well as aligning these results within the current body of literature. The discussion includes dialogue centred upon the educational settings of the participating institutions in this study. Implications of these findings are also discussed as well as potential directions for future research.
Chapter 6: Discussion

The results of this study shed light on the background, resources, relationships and experiences that empowered URM female students towards persistence in STEM within the context of a liberal arts college environment. This chapter offers a contextualised discussion of these research results set within the unique landscapes of women’s liberal arts colleges, coeducational liberal arts colleges and an HBCU, through exploring the array of experiences that sustained retention and affirmed affective behaviours for URM female STEM students. Each section of this chapter pertains to a specific aspect of the proposed conceptual model derived for this study (see Figure 4) and includes discussion of the research results based on the theoretical frameworks chosen for this study as well as situating the results within the current body of literature. Dialogue in the first section of this chapter centres upon the demographic and academic influences of pre-college background for URM female STEM students and those aspects of inherited cultural and social capital that may affect persistence in college. Set within particular college climates and cultures, the second section offers a discussion on the college experience for URM female STEM students who have persisted past their second year of study, with an emphasis on the acquisition of education enhancing capital. The third section considers how the formation of science identity for URM female STEM students may be influenced during the college experience and the fourth section offers a discussion of the influential relationships outside the arena of the higher education environment that affect persistence for URM female STEM students. The last section of the chapter offers summary thoughts on the theoretical frameworks that were explored in this study.
The Influence of Pre-College Background

Overall, while the URM female STEM students in this study appeared to be less academically prepared than their non-URM counterparts, they still possessed a strong background in preparation for pursuing a tertiary degree in STEM. On average, the URM females students in this study completed 5.6 STEM subjects and 1.4 AP STEM subjects in high school, compared to 6.23 STEM subjects and 1.73 AP STEM subjects for non-URM female students, and the self-reported HS GPA for URM females was 4.14 compared to 4.78 for non-URM female students (5=A/A-, 4= A-/B+). While these comparisons may be statistically significant, they more importantly may point towards what might be considered a threshold entry point/average for young women hoping to successfully pursue a STEM degree at a liberal arts college.

Where these two cohorts of students did not differ in their academic preparation was in their participation rates in a STEM related enrichment program and their participation rates in AP Calculus courses in high school. More than 60% of both the URM and non-URM female STEM students in this study enrolled in AP Calculus (or higher level IB Mathematics) during high school. This participation rate is striking, because in comparison less than 10% of all secondary students in the U.S. take AP Calculus while enrolled in high school (Mattern, Shaw & Ewing, 2011). Mathematics is often seen as a “critical filter” in paving the way towards successful careers in a STEM related field (Sells, 1973). In an earlier study, Robinson (2003) compared outcomes for both minority and non-minority high school students and found that students who enrolled in AP Calculus, regardless of ethnicity, selected STEM paths at college at a higher rate than non-STEM paths. Additionally, Correll (2001) found that young women who enrolled in AP Calculus were three times more likely than those not enrolled to pursue a STEM related major in college. Using multinomial logistic
regression analysis, Tai et al. (2010) determined that students who completed AP Calculus were four times more likely to select STEM fields of study in college such as engineering or physical sciences versus a non-STEM field. While these prior research studies connect high school course taking to the selection of a STEM major in college, the results of this study indicate the preparation necessary for URM female STEM students to not only select, but to persist in a STEM major within a selective liberal arts college context. Not only did a large percentage of URM female STEM students in this study complete AP Calculus, but on average URM female STEM students completed 1.4 AP STEM subjects. Within the interviews, most URM female STEM students indicated that taking AP STEM courses in high school was the primary reason for feeling prepared for the rigours of a STEM degree program at university. While participation rates in AP STEM classes for URM female STEM students is significantly lower than participation rates for non-URM female STEM students, this threshold for persistence is similar to the results found by Shaw and Barbuti (2010) where they determined that taking at least one AP STEM subject exam in high school was related to persistence for students majoring in STEM during their third year of university study.

Participating in a rigorous mathematics program throughout all of high school appears essential for URM female students continued success in a STEM field of study at college (Foltz et al., 2014). However, not all students have access to such rigorous high school curriculum, and several of the colleges in this study have developed programs that guide URM female STEM in filling any gaps in the mathematical content required for success in STEM. Woodard College’s Emerging STEM Talent program, Cahill University’s Success in Engineering Initiative, and Creswell College’s Calculus STEM Support group are all programs aimed at offering first year students from under-resourced high schools the opportunities to increase their mathematical confidence and
knowledge for future success in STEM courses. These programs not only provided opportunities for students to “catch-up” in their mathematical skills, but these groups, often hosted by a minority professor of colour, also provided a cultural community where female STEM students learned to struggle together towards success. The effects of communities that struggle together are further discussed later in this chapter. While many URM female STEM students do matriculate into college with a solid STEM foundation, the further enrichment offered by these mathematics skills programs appears to offer the necessary support for those URM female STEM students who enter college with a desire to pursue STEM, but who may be lacking in competencies necessary for success. Regardless of their initial mathematics backgrounds upon entering university, URM and non-URM female STEM students who completed at least two years of STEM study at college did not display a statistically significant difference in Mathematics Self-Concept. While persistence may hinge upon an understanding of self-concept (McCombs and Whistler, 1989), this study only collected data at one point in time, and any comparisons in Mathematics Self-Concept over time between these two groups of students was not captured.

Not only does rigorous STEM course taking in high school lay a solid academic foundation upon which URM female STEM students can build while in college, but the relationships nurtured between teachers and students within high school STEM courses, as demonstrated in this study, positively influenced students’ selection of a STEM major in college. In a study conducted by Fries-Britt, Younger and Hall (2010), students were motivated to pursue a STEM path because of teachers who affirmed their aptitude and abilities. While STEM course taking may increase students’ knowledge, the positive social ties experienced between teachers and students allowed teachers to act as empowerment agents which enabled and inspired students to see themselves as potential
future STEM professionals (Ovink & Veazy, 2011; Stanton-Salazar, 2011). Most of the URM female STEM students interviewed in this study indicated an inclination towards the sciences well before college. This juncture is critical for URM female students as they usually indicate interest in majoring in STEM before college matriculation. Additionally, regardless of ethnicity, students rarely switch into a STEM field if they are first leaning towards a non-science path (Syed, 2010). In this study, only 4% of both URM and non-URM female STEM students switched into STEM after first declaring a non-STEM major. Women who stayed in STEM started in STEM, so affirming a student’s aptitude in science or mathematics during secondary school may prove critical not only in acquiring the academic skills required for STEM but also in the formation of a student’s science identity (Carlone & Johnson, 2007).

The majority of female students in this study attended public high schools. Yet a noteworthy 30% of both URM and non-URM female STEM students attended private high schools (either Catholic or non-religious). This is triple the national average as approximately only 10% of U.S. students attend private high schools (NCES, 2015). As each college’s admission’s strategy was not a focus of this study, it is difficult to determine if this increase is perhaps more reflective of the types of schools targeted as part of the recruitment practices of the liberal arts colleges in this study. However, research shows that students who attend a private high school graduate from college at near double the rate compared to students who attended public high school (62% Catholic HS; 57% other private HS; 31.1% public HS) (Lauff & Ingels, 2013). Neal (1998) suggests that minority students benefit from private high school attendance since many public urban high schools lack equivalent resources. Although a deeper discussion on the types of high schools that foster persistence for URM female STEM students is beyond the scope of this study, private high schools are commonly known to offer
students a somewhat similar environment to a liberal arts college – smaller class sizes, more accessibility to faculty, more personal attention, and an increased college-going, college-persistence habitus. The smaller school size that private schools offer has also shown to improve the academic gains of minority students (Lee & Smith, 1997). For some URM female STEM students, particularly first-generation college students, the secondary school environment of a private institution may provide opportunities for access to the cultural and social capital necessary for admission into a selective college and STEM program. In this study, almost a third of URM female STEM students were the first in their families to attend college.

When compared to their non-URM counterparts, URM female STEM students presented with significantly lower levels of inherited cultural capital when measured by parents’ education, parents’ occupations and family income. For URM females STEM students, their mothers were more educated than their fathers, and nearly half of their fathers did not possess a college degree. However, for non-URM female STEM students the trend was reversed as more than half of their fathers had earned a post-graduate degree. Also, parents of non-URM female students were almost twice as likely as parents of URM female students to be in a STEM related occupation. One might assume that these lower levels of capital would also translate into similarly parallel displays of habitus as transferred from parent to student. But that was not the case in this study. Parents of URM female STEM students held near equal educational aspirations for their daughters as did parents of non-URM female STEM students. In their study that explored the experiences of successful URM STEM graduates, Foltz et al. (2014) similarly found that, “students’ families and communities possessed a habitus that values both going to college in general and pursuing a degree in the sciences in particular” (p. 9). Chavira and Mena (2011) conclude that the commonly held view
that ethnic minority parents display lower educational ambitions for their children is indeed “a myth” (p. 78). While parents of URM female STEM students saw education as key to their daughters’ success, and held high academic aspirations for their daughters, they often did not possess the knowledge of how to help their daughters navigate the path towards a STEM degree (Chavira & Mena, 2011; Syed et al., 2011). Parents’ habitus in the form of their educational expectations for their daughter to attain a college degree did not directly translate to the parents’ ability to supply the education enhancing capital required for their daughter’s college persistence.

Although some prior studies have assessed parent socialisation variables, as it relates to cultural capital, to exclusively consider parents’ education, parents’ occupations and family SES (Winkle-Wagner, 2010), Perna (2000) and Wells (2008) expanded this narrow view of family related capital variables by widening the parameters to include schools as potential brokers of cultural capital. This view challenges the notion that the transmission of the types of cultural and social capital vital for students’ progress through the academic pipeline is channeled exclusively through families. In assessing the roles that outside agencies such as schools play, Goldthorpe (2007) asserts that, “…the family is not the only locus of either the creation or transmission of cultural capital…educational institutions also can, and do, play a major role in this regard” (p. 16). For URM female STEM students in this study, parents’ level of education, occupation and SES were not predictors of the acquisition of STEM related cultural capital during college. However, the encouragement to attend college that was received from adults outside of the family, such as teachers, counsellors or personnel from college preparation programs, was a predictor of cultural capital acquired during college. Independent from their families, URM female STEM students in this study gained important knowledge and skills necessary for successfully
navigating the college admissions process directly from their schools and/or college preparation programs.

In the U.S., the college admissions process is complex and arduous, and often begins with sitting for standardized admissions tests (SAT/ACT) in Year 11. These tests, which are critical in the college admissions process, are three to four hours in length and are offered on various weekends throughout the academic year. Not every school is a testing centre and students often have to travel outside their home communities to complete these tests. Students usually sit for these exams several times in Year 11 and/or Year 12, as most colleges often accept a student’s best results and it is often in the student’s best interest to take these tests multiple times. For some students, these exams are expensive, and low SES students may be offered a fee waiver if they are aware of the process of applying for one. Although most colleges require either the SAT or the ACT as part of their admission requirements, a small group of colleges are “test optional” and choose to look more holistically at a student’s cumulative academic record from Year 9 through Year 12. One of the institutions in this study, Whitt College, is a “test-optional” university and does not require students to submit standardized admissions tests as part of the application process.

In this study, URM female STEM students received significantly more assistance in preparing for admissions tests from their schools or college preparation programs than did non-URM female STEM students, illustrating the point that schools and/or educational programs do indeed provide institutional agency in the transmission of the cultural capital required for successfully navigating the university admissions process (Stanton-Salazar, 2011). While families may have offered important emotional resources for building aspirations, key institutional agents outside the family contributed
towards the knowledge and skills necessary for progression towards a tertiary education path (Syed et al., 2011).

It appears that college preparation programs were very influential in the lives of the URM female STEM students interviewed in this study. That was an unexpected result and in retrospect it would have been beneficial to further explore the impact of college preparation programs through including some prompts in the questionnaire to more broadly survey all URM female STEM student participants regarding these types of programs. Students in this study participated in both local and national programs such as the Upward Bound program and the Posse Scholars Program. In a national study, students who participated in the Upward Bound program were four times more likely to earn their college degree than students demographically similar, yet who did not participate in a comparable program (Gullatt & Jan, 2003). More than half of the interviewees in this study (16 out of 30) participated in a college preparation program, and of the ten first-generation students interviewed, all but one participated in a college preparation program. Although based on small numbers, this may be a strong finding as first-generation college students are almost twice as likely to exit STEM and leave college altogether than their peers whose parents completed college (Engle & Tinto, 2008). In this study, URM female STEM students were three times more likely to be a first-generation student when compared to their non-URM counterparts. Although the URM female STEM students in this study may have lacked certain levels of cultural capital traditionally assumed as transferable from their families, these young women appropriated key sources of capital outside their families and from these programs.

These college preparation programs guided and prepared students not only for college access but for college success. They offered counselling, tutoring, academic skills enrichment, mentoring and financial support to students who often have the
greatest need for assistance in the college-going process, but who often also lack access to those resources (Tierney & Jun, 2001; Avery, Howell & Page, 2014). For the URM female STEM students in this study, participation in a college preparation program helped fill knowledge gaps about the college application process, knowledge assumed by many who come from more privileged backgrounds. These college preparation programs also helped students to form cultural enclaves with other high-achieving students from diverse backgrounds who shared the common goal of admission to university (Kuh & Love, 2000). Tierney and Venegas (2006) posit that these types of fictive kin networks with other high achieving peers may produce a culture of success, paving a path towards college attendance through increasing social capital. Several of the women in this study maintained close contact with the directors, mentors and peers from their college preparation programs and credit these relationships with offering continued encouragement throughout the difficult road of pursuing a STEM degree in college. These programs not only provided access for students to acquire the cultural capital necessary for successfully transitioning to the college environment but also increased students’ access to social capital through resource rich relationships and continued networking throughout college with program participants. “Pre-collegiate academic development programs appear to be an important catalyst for institutionalizing school transformation within a context that promotes and achieves equitable postsecondary access for all students” (Gullatt & Jan, 2003, p.2).

Not only did URM female STEM students receive significantly more assistance in applying for financial aid through the guidance and support offered by their college preparation programs and/or their school counsellors when compared to non-URM female STEM students, they also indicated they were more satisfied with their financial aid-packages as well. Since parents of lower SES or educational levels may lack the
knowledge and experience to sort through financial aid applications and financial aid packages with their daughters, schools and college preparation programs offered critical information in understanding the affordability of college (Perna, 2006). In this study, families of URM female STEM students may have been limited in their knowledge of the financial requirements of pursuing a college education as 40% of mothers and 48% of fathers of URM female STEM students did not complete a bachelor’s degree compared to 20% of mothers and 18% of fathers of their non-URM counterparts.

Most of the colleges in this study guaranteed to meet most, if not all, of a student’s demonstrated financial need to attend their college (Whitt, Woodard and Creswell - 100%; Cahill - 95%; Hayden - 85%). For many of the URM female STEM student interviewed in this study, the financial aid package determined which college to attend and significant scholarships additionally influenced institutional selection as well. These results parallel Foltz et al.’s (2014) study in which URM graduates who persisted in STEM credit the assistance they received through financial aid as both an “onramp and a guardrail in the educational pipeline” (p.7). Sustaining financial support for URM female students is critical in increasing diversity not only within the college setting, but in STEM fields as well, as this form of economic capital acquired through higher education institutions is essential for persistence (Hurtado et al., 1998).

In summarising the background characteristics of URM female STEM students who have persisted beyond two years of STEM study, many were well prepared for success in STEM through rigorous mathematics and science course taking in high school, particularly participation in AP Calculus. Although non-URM female STEM students may have been more academically prepared, the preparation demonstrated by URM female STEM students may indicate a threshold level required for success in STEM at these selective liberal arts colleges. However, to help remediate academic
background deficiencies, several of the colleges offered specific programs to assist under-resourced URM female STEM students who may have lacked certain skills or confidence levels necessary for persistence in STEM. Families of URM female STEM students held high academic aspirations for their daughters, and may have offered a form of *familial capital* to their daughters rooted in cultural knowledge and intuition gained from ethnic kin and community (Yosso, 2005, p. 79). While this may have fuelled their daughters’ drive to attain a college degree, the education enhancing capital required for college persistence came from a multitude of sources outside of families.

Schools and college preparation programs provided crucial opportunities for students to acquire the cultural and social capital required for access to college through both the transfer of specific knowledge and skills as well as networking through resource rich relationships with teachers, counsellors and college-going peers. Colleges provided significant economic capital through financial aid awards to sustain students on their college journeys. The accumulation of social and cultural capital at the pre-college juncture was critical for URM female STEM students to successfully transition to the college environment. Yet, the desire to pursue a STEM field of study upon matriculation seems to have been most influenced through a combination of rigorous STEM course taking in high school together with the relationships formed with STEM teachers who acknowledged and affirmed URM female STEM students’ abilities and talents in science and/or mathematics. This recognition from teachers is also instrumental in the development of a positive science identity for young woman of colour (Carlone & Johnson, 2007). While URM female STEM students who stayed in STEM started in STEM, the experiences and personal agency required for persistence after college matriculation takes on a new and different complexion once a student arrives on campus.
The College Experience for Those Who Persist

The students in this study attended private, liberal arts colleges which are known for the attention and focus they invest in undergraduate education programs, including increased access to faculty and early opportunities for research. Liberal arts colleges also demonstrate more success in retaining undergraduates in STEM (Griffith, 2010; Rine, 2014) and compared to bachelor’s degree STEM entrants from public 4-year institutions, STEM students who attended private institutions are less likely to switch out of STEM and into a non-STEM major after matriculation (Chen & Soldner, 2013). When looking at the ratio of PhDs earned per graduate, liberal arts colleges produce twice as many eventual Science PhDs than other types of baccalaureate institutions (Cech, 1999) and the specific colleges in this study were selected based on their success in graduating high numbers of women who eventually earn PhDs in STEM fields.

The three types of colleges in this study (coeducational, women’s and HBCU) are quite unique in landscape and mission, and these differences are immediately evident when stepping onto each of the campuses – the striking absence of men at a women’s college, the strong presence of students of colour at an HBCU, and the more typical tertiary environment at a coeducational college. However, aside from the obvious dissimilarities driven by their respective mission statements, these colleges share a common vision of embracing diversity while working diligently to create academic environments geared towards the success of all students. The vision embraced by each college was one that promoted goals of both equality and equity (Harper, 2009).

Although there is a plethora of programs at each college that supports students from diverse ethnic backgrounds and students specifically in STEM, URM female STEM students in this study were twice as likely to indicate that they considered quitting college when compared to their non-URM counterparts. URM female STEM
students’ indication that they had considered quitting college was highest at Hayden University (HBCU) although not significantly different from the other college types. This may be reflective of the overall lower retention rates exhibited by Hayden (70%) when compared to the other colleges in the study (94-97%), or it may be attributed to an increased sense of resilience URM female STEM students at an HBCU possess.

In analysing attrition factors in STEM at a liberal arts college, Rask (2010) found that grade point average (GPA) was one of the most influential reasons for attrition in STEM. In this study, URM female STEM students’ mean self-reported GPA was 3.29 compared to 3.50 for non-URM female STEM students. Although the difference between the measures of GPA for URM and non-URM female STEM students was statistically significant, both sets of GPAs are notably above the national average of GPAs for those who study STEM (3.0) as well as for those who study non-STEM (3.2) courses, as reported by the U.S. Department of Education (2012). In their study which explored the experiences of minority women who persisted beyond college and into STEM related careers, Carlone and Johnson (2007) noted that all of the 15 women in their study reported mean GPAs between 3.10 and 3.53, also above the national average of GPAs for those who study STEM. The GPAs of URM female STEM students in this study may be more indicative of a persistence threshold for those pursuing STEM related majors within the context of a selective liberal arts college.

It is commonly understood that in higher education, grading policies are harsher in STEM courses (Rask, 2010). In evaluating the effects of grades for students majoring in life and physical science majors, Ost (2010) found that females in particular are more influenced by their GPA when compared to males. Within a STEM context, students are “pulled away” by their high grades in non-science courses and “pushed out” by their low grades in their STEM related subjects (p. 1). For some of the URM female STEM
students in this study, the grades received in their STEM courses were clearly a source of discouragement as students perceived their grades were not fully reflective of their knowledge or effort. While it may have caused some to consider switching out of STEM, URM female students who persisted were able to “redefine” success and achievement apart from their grades. In some ways, this ability to re-shift their perspective, with the help of faculty, mentors, peers and family support produced a resilience to persist (Seymour & Hewitt, 1997). When highlighting their academic success though, URM female STEM students often attributed their achievement to their intentional effort and hard work, and not necessarily to some fixed level of aptitude. This perception of the source of their personal academic achievement may have supported their persistence efforts. “When students believe that their intelligence can increase, they orient toward doing just that, displaying an emphasis on learning, effort, and persistence in the face of obstacles” (Dwek, 2008, p. 4).

URM female STEM students were almost twice as likely to indicate that they seriously considering leaving STEM when compared to non-URM female STEM students, and this was most significantly correlated to perceptions of competitiveness in STEM classes. Other variables that also significantly correlated with a URM female STEM students’ serious consideration of abandoning STEM were college GPA, receiving adequate financial aid, ethnic identity commitment, racial climate, science identity, and a sense of belonging in STEM. These factors, which offer an entry point in developing a diagnostic understanding of the relative risks to persistence for URM female STEM students in these liberal arts colleges, are all further discussed in this chapter in the context of the guiding research questions. As a springboard for future research, capturing data from URM female students who have actually left STEM, and comparing with data from URM female students who have stayed and persisted in their
STEM degree programs, could offer deeper insight to the relative risks of attrition associated with persisting in a STEM major at a liberal arts college.

For some URM female STEM students, the racialized environment of studying and learning at a PWI was one of the most notable obstacles experienced in the pursuit of their STEM degree. Charles and colleagues (2009) assert that the ongoing effect of racial segregation in the U.S. plays out in “subtle ways that strongly conditions minority students’ grade achievement” (p. 230). Depending on which institution they attended, the URM female STEM students in this study lived at residential colleges in which non-URM students comprised anywhere from three to eighty-two percent of the total student population. Even with this striking difference in racial composition among the colleges in this study, many of the comparisons made regarding the experiences of URM female STEM students at the different college types yielded surprisingly similar results, with a few notable exceptions. However as one might expect, given the demographic breakdown at the various colleges, the racial climate experienced at these different campuses is one area of comparison that proved highly significant.

The Racial Climate factor in this study comprised four items: (a) experiencing alienation on campus due to ethnicity, (b) experiencing alienation in STEM classes due to ethnicity, (c) experiencing racial discrimination from teachers, and (d) experiencing institutional discrimination. In some ways, the first two component items of the Racial Climate factor relate more to student-to-student interactions, while the latter two relate more to student-institution interactions. While the majority of URM female STEM students did not indicate that they experienced a negative racial climate on campus or in the STEM classroom, there is a striking difference in student responses based on whether or not students attended a PWI or an HBCU. In this study, over 40% of URM female STEM students who attended a PWI indicated they experienced feelings of
isolation in the STEM classroom and approximately 30% indicated they experienced feelings of isolation on campus. This is compared to zero percent on both these measures for URM female STEM students who attended an HBCU. In their research which explored the academic and social experiences of students’ during their first two years of college, Charles and colleagues (2009) found that a third of minority students experienced some level of defensiveness due to their ethnicity and a quarter of students recounted offensive comments from their classmates. These researchers also contend that minority students often have to cope with combating negative stereotypes of minority underachievement within the classroom setting.

In this study, some URM female STEM students reported experiencing lowered expectations from other students, particularly lab partners, as well as hearing subtle racist remarks from classmates. It is interesting, however, how URM female STEM students in this study reacted to both these forms of racism. In the first instance, URM female STEM students became defensive and developed skills in standing up for themselves when classmates doubted their work. However, when dealing with microaggressions such as hearing subtle derogatory comments, URM female STEM students in this study tended to downplay these racially charged remarks choosing instead to believe that non-URM students’ comments came more from ignorance than from the desire to inflict intentional harm or racist intent. This type of response is consistent with other research. In their qualitative study of minority students in professional university programs, Hendricks and fellow researchers (1996) found minority students tend to “depersonalise” negative racial comments in order to maintain and develop the agency necessary for persistence (p. 121).

In order to combat the effects of these microaggressions, and develop the agency to persist, students in this study formed cultural enclaves of supportive groups with
other students of colour in STEM in which they learned to struggle together in order to push ahead (Kuh & Love, 2000). While some of these groups developed organically within STEM classes, other students established these empowering relationships through their involvement in campus diversity organisations, STEM retention and scholar’s programs or professional clubs such as the National Society of Black Engineers, which was an important influence in the lives of URM female STEM students at Cahill University. The positive effects of finding other students from similar cultural backgrounds with whom to struggle also extended beyond campus networks, as URM female STEM students additionally experienced solidarity with other minority students through participation in outside conferences. As one participant noted, talking with others who understand the struggle “is such a profound thing”. What bonded these women was a common appreciation of the struggle they each faced as students of colour in pursuing and persisting in STEM.

These academic and social “counterspaces” not only provided safe boundaries, but spaces where minority students communally developed the “navigational” and “aspirational” capital required to direct the course of their education while resisting the subtle forms of racism found on their campuses (Yosso et al., 2009, p. 660; Yosso, 2005, pp. 77, 79). For URM female STEM students, these cultural enclaves created a dynamic in which members aided and empowered each other with the specific goal of completing their college degree (Tierney & Venegas, 2006; Williams, 2010; Foltz et al., 2014). In their work on college attrition and persistence, Kuh and Love (2000, p. 207) posit that students who come together in forming cultural enclaves that value achievement and persistence are more likely to finish college and receive their degrees. I don’t think one can overestimate the significance of these cultural subgroups in empowering URM female STEM students towards degree completion. Amidst
opposition and barriers, these cultural enclaves allowed participants to develop a form of “aspirational” capital that collectively fuelled their dreams of completing a STEM degree (Yosso, 2005, p. 77). Not only did these networks provide vital sources of education enhancing capital that appeared paramount to their success, but these enclaves provided a platform from which URM female STEM students worked together to resist the negative effects of racism and the alienation that comes from the paucity of URM female students in STEM (Kuh & Love, 2000; Yosso, 2005; Yosso et al., 2009).

The URM female STEM students interviewed in this study believed that the most significant way in which their colleges could improve the success of women of colour in STEM would be through increasing the diversity in both the faculty and student body. The majority of students focused their responses on issues related to building stronger communities, fostering open dialogue, and building collegial networks through diversifying the STEM student body and faculty. On their campuses, students not only desire to see themselves reflected in their college peers, but also in those who teach, instruct and guide them as part of their college experience. The current body of literature is replete with examples that highlight the social isolation experienced by URM students across America’s campuses. Within the current landscape of higher education in the United States there is certainly a cry for more equity in hiring practices, as evidenced by recent protests and uprisings across America’s college campuses during the period in which this data was collected (campus demands, n.d.)

While there was a significant difference in URM female STEM students’ perception of alienation on campus or in STEM based on the type of college attended, there was not a significant difference in URM female STEM students’ responses based on college type to experiencing racial discrimination from teachers (7% Coed; 12% Women’s; 5% HBCU). The alienation that URM female STEM students may
experience within the STEM classroom environment does not appear to be significantly influenced through their interactions with teachers. This findings is consistent with Charles et al. (2009) and their research on the lives of college students in the U.S. in which they observe, “this racialization stems from the actions of students themselves rather than faculty or other authorities” (p. 231).

URM female STEM students’ responses regarding their perceptions of institutional level discrimination did not differ significantly based on attendance at either a PWI or an HBCU (29% Coed; 27% Women’s; 25% HBCU). However, when comparing URM to non-URM female STEM students across college types, a significant difference was found. Before arriving on campus, each woman, minority or non-minority, brings with her an accumulation of life experiences that affects how she responds and interacts with the campus environment and those within that environment. Underrepresented racial minority women and non-minority women may see the world through different lenses, impacting their perceptions of their relationship with those who hold positions of authority, and in this case, faculty and institutions (Miller et al., 1998). Even though these sub-samples were small, it was surprising that URM female STEM students at Hayden University (HBCU) indicated experiencing similar levels of institutional discrimination when compared to URM female STEM students at the PWIs. Perhaps URM female students at Hayden, when asked if they experienced “institutional discrimination”, may have expanded their interpretation beyond their particular HBCU higher education institution and considered other personally discriminatory situations related to other types of institutions. In their study that explored racial stereotypes at both HBCUs and PWIs, Chavous et al. (2004) determined that while minority students at HBCUs may experience a greater sense of belonging within their institutions, they are not “insulated” (p. 12) from the effects of
discrimination solely because students of colour are a majority presence on their campus.

For URM female STEM students in this study, Racial Climate was significantly correlated to a sense of belonging within the STEM setting during their first two years of study; as URM female STEM students’ positive perceptions of racial climate increased, their sense of belonging in the academic environment of STEM also increased. URM female STEM students from Hayden University (HBCU) not only indicated the most positive perceptions of racial climate when compared to women’s colleges and coeducational colleges, but also indicated experiencing the highest levels of a sense of academic belonging in STEM during their first two years of study (with medium effect size). Students of colour, as a majority presence at an HBCU, may not have to contend with feelings of being an outsider on campus and in the STEM classroom, impacting their sense of belonging within the academic environment. While other studies have highlighted the negative effect that racial climate has towards sense of belonging at a PWI (Hurtado & Carter, 1997; D. Johnson, 2011), this study highlights the positive effect that an affirming racial climate at an HBCU may have towards a positive sense of belonging in the STEM environment for URM female STEM students. Perceptions of racial climate are complex and challenging, and the level of discussion it merits is beyond the scope of this study. Closer comparative research on the complexities of racial climates at different types of higher education institutions may be worthwhile as the effects of racial climate are far reaching within the college environment, the college campus and in the lives of URM female students in their pursuit of their STEM degree.

For all students in this study, URM and non-URM alike, there was a significant correlation between students’ perceptions of a positive racial climate with students’
assessments of their colleges’ commitment to diversity and its’ effective programs. URM and non-URM female STEM students did not differ significantly in their perception of their colleges’ diversity efforts and their effective diversity programs, and this may be attributed to the efforts of each of these colleges towards embracing cultural diversity while also creating opportunities for students to grow in their understanding of their own cultural identities. Additionally, when comparing URM female STEM students’ responses based on college type, women’s colleges gave highest marks to their colleges’ diversity efforts and effective programs when compared to coeducational colleges or HBCU. Though the differences in responses based on college type was non-significant, it yielded a small to medium effect size. Historically, women’s colleges have been known to promote multicultural efforts and campus-wide conversations about race within their campuses (Kinzie et al., 2007).

Tierney’s (1999) model of cultural integrity firmly places the onus on institutions of higher education to “accommodate” and “honour” students’ ethnicity within the academic setting (p. 83). He asserts that students who are allowed to embrace and affirm their cultural identity within the academic and social environment of university increase their probabilities of graduating. It was clearly evident that each of the colleges in this study worked diligently towards promoting the benefits of an inclusive community while guiding students in finding a cultural home on campus that allowed them to explore their cultural heritage with others and within the context of an affirming academic community. All of the colleges hosted cultural groups for Black students, with several of the colleges providing a dedicated space or house for gatherings. Woodard College’s house for Black women even hosted chemistry tutorials under the umbrella of their cultural group. All of the colleges, aside from Hayden University (HBCU) also had active Latino/a groups on campus where students could
find a cultural home through which to enhance their cultural experience and explore their cultural identity. All five of the colleges had ethnic *heritage months* that celebrated the various cultural/ethnic groups represented on their campuses through events, gatherings, talks and concerts. Heritage months were well publicised at each college. Visitors to Woodard College’s Latina heritage month would be greeted by photo-essays prominently exhibited throughout campus. These displays presented observers with challenging prompts that hopefully facilitated deeper and worthy discussion on issues of race and racism relevant to students and the wider community.

Ethnic student organisations and the relationships formed through those organisations, provided avenues for cultural validation and allowed students to establish sustaining networks with both individual and collective cultural agents (Museus & Quaye, 2009; Museus, 2008). Grandy (1998) found that minority support not only helped science students overcome the deficits of coming from a disadvantaged background but was also the most significant predictor variable that influenced science ambition. Tierney’s (1999) concept of cultural integrity was one of the theoretical tenets explored in this study, and it was evident that each of the colleges in this study made a significant investment in not only providing the resources for students to find a cultural home on campus in which they were affirmed but also in engaging the wider campus community in meaningful dialogue on issues of race. But how does Tierney’s concept of cultural integrity affect URM female students and their ability to acquire the education enhancing capital required for persistence in STEM? And how do prior levels of cultural capital assumed from family and other institutional agents affect the capital acquired during college as well?

These questions were explored through a regression analysis, where it was determined that the leading predictor for acquiring the cultural capital necessary for
persistence in STEM was a URM female STEM student’s belief that her college takes issues of diversity seriously and has effective programs. As Milem, Chang and Antonio (2005) observe, “students’ assessments and perceptions of their institution’s overall commitment to diversity are influential in determining whether or not they are able to benefit from diversity” (p. 11). While parent socialisation variables (education, occupation, income) did not significantly correlate to this measure of cultural capital for URM female STEM students (Cole & Espinosa, 2008; Espinosa, 2011), other variables that did predict STEM specific cultural capital acquired during college were a URM female STEM student’s commitment to her ethnic identity, and the encouragement received from adults outside the family (i.e. teachers, school counsellors, college preparation program personnel) to attend college. These findings offer a quantitative validation of Tierney’s (1999) model of cultural integrity as well as Stanton-Salazar’s (2011) framework of institutional agents. Contrary to other theories that purport that students need to break ties with their cultural backgrounds and home communities in order to assimilate to the predominant culture within their educational environments (Tinto, 1987; Fordham, 1988), URM female STEM students in this study who held a strong commitment to their ethnic identity and who believed their colleges took issues of diversity seriously and had effective programs, also indicated that their colleges provided them with the skills and knowledge for a successful career in STEM. Milem, Chang and Antonio (2005) posit that “a student’s actual engagement with diversity is a more direct and powerful way to realize developmental gains” (p. 12). They also suggest that “being in an environment committed to diversity may also contribute to students’ development and influence their participation in different campus activities” (p. 12).
When looking at the supportive activities offered to URM female STEM students on the academic front, all of the colleges in this study had specific programs that supported minority students’ mathematics achievement. The specific program at Cahill University (SIE) also matched students with professional mentors working in industry that not only acted as role models but also provided access and networking opportunities for students to assume summer internship positions within their companies. URM female STEM students often praised these support programs and affirmed the role they played in their persistence. Unlike Huang et al. (2000) who suggest that remedial programs targeted at specific groups may negatively associate participants with inherent issues of underachievement, URM female STEM students in this study did not report experiencing any type of negative stigma through participation in support programs aimed specifically at URM or under-resourced students. However, that might be due to how the names of these programs were framed or the means through which students were selected to participate. Although pseudonyms were assigned to the names of the various programs highlighted in this study, the actual program titles included words such as “success” and “scholar”. These specific words focus more on student potential and not on some level of past failure or deficit requiring remediation. Also, for several of these retention-type programs, students needed to either submit an application or receive a personal invitation in order to attend. The positive framing of program titles and the perceived selectivity of these programs may have reduced potential negative stigma associated with participation (Charles et al., 2009).

Although specific programs at each college promoted improved academic gains for URM female STEM students, there was also a vast array of programs and support structures in place for all students in which URM female STEM students could also
participate, such as Supplementary Instruction at Hayden University and Woodard College, the Computer Science Peer Mentors Program at Creswell College, or the academic centres on each campus that offered individual or group tutoring across a range of many subjects for all students. More than half of URM and non-URM students alike sought additional academic help outside the classroom in support of their STEM studies. These academic support programs were embedded within campus cultures that promoted high levels of excellence and achievement for all students, and in which many students participated. For all students, seeking additional academic assistance outside the classroom, when needed, was the norm at these campuses. This may have negated the potential effects of negative stigmatization for URM female STEM students who sought academic help through specific programs targeted for improving the success of URM STEM students. For URM female STEM students who persisted, engagement was high across a platform of many academically supportive programs.

In looking at involvement outside the classroom, URM female STEM students participated in more curricular and extracurricular activities than did non-URM female STEM students, with medians of five activities versus four activities, respectively. URM female STEM students who persisted were exemplars of engagement on campus in both social and academic domains. Pascarella and Terenzini (2005) suggest that negotiating various responsibilities through social involvement within the multiple contexts of campus life may take time away from studying and ultimately have a negative effect on academic achievement. However, the women in this study were highly invested in both social and academic endeavours on campus. When compared to non-URM female STEM students, URM female STEM students were ten percentage points more likely to be a member of a professional club or have a professional mentor, and two thirds of URM female STEM students participated in research.
The literature speaks clearly and definitively of the benefits of research participation for the retention of minority students in STEM (Hurtado et al., 2007; Chang et al., 2014). A common attribute of each of the colleges selected for this study is their commitment to undergraduate research programs for women in STEM. Nearly two thirds of the URM female STEM students in this study participated in at least one research experience. Each of the colleges in this study provided various opportunities for students to engage in research through working in labs during the academic school year, and for some colleges these opportunities were provided through STEM scholars’ programs. Additionally, all the colleges in this study provided multiple opportunities for students to engage in formal summer research programs that also offered generous financial stipends. Several of the colleges also offered financial assistance for students to present their research findings at academic conferences or symposiums.

In the lives of minority students in STEM, research experiences clarify students’ career goals, increase confidence, enhance academic gains, and shape students’ identities within the scientific profession (Hunter, Laursen & Seymour, 2007; Hurtado et al., 2007; Thiry, Laursen & Hunter, 2011; Villarejo, Barlow, Kogan, Veazey & Sweeney, 2008; Russell, Hancock & McCullough 2007; Seymour, Hunter, Laursen & DeAntoni, 2004). The hands-on nature of research experiences in this college context also permits students to increase their self-efficacy towards conceptual aspects of science (Hurtado et al., 2009). Within the context of a liberal arts education, research opportunities also allow URM female STEM students to experience a unique socialisation process into science through collaborative research ventures with faculty (Beaver, 2001). Specific within the liberal arts college setting, Beaver (2001, p. 372) asserts “being active in research, but not in a major research university, research institute, or industrial research lab, affords a unique vantage point for providing a
clearer perspective on the nature and function of collaboration” (p. 372). Due to the lack of doctoral students on these campuses, a great advantage for STEM students at liberal arts colleges in general is the ability to collaborate first-hand with faculty on research projects, with students often listed as co-authors on a significant portion of scientific papers which their professors submit for publication (Beaver, 2001). This research culture may in part explain why liberal arts college graduates outpace graduates from other types of institutions of higher education in participation in PhD Science programs (Cech, 1999).

In this study, URM female students were more likely to participate in STEM related professional clubs than non-URM female students (31% vs. 21%). However when looking at professional club participation for URM female STEM students across institutions, a significant difference emerges. More than half of the URM female STEM students at coeducational colleges (52%) were members of a STEM related professional club compared with only 20% participation in professional clubs from URM female STEM students from the other college types (women’s, HBCU). This may explain why URM female STEM students from coeducational colleges, compared to women’s and HBCU, demonstrated a greater belief they were receiving the academic preparation for a successful STEM career as this indicator was also positively correlated to participation in a professional club. The colleges in this study offered a variety of STEM related professional clubs in which students could participate- The National Society of Black Engineers, The Society of Women Engineers, Minority Association of Pre-Health Students, Society of Hispanic Professional Engineers to name a few. These groups not only provided opportunities for students to collectively extend and apply classroom acquired knowledge, but also enhanced students’ social capital through networking with peers on campus and with other STEM leaders at national conferences. In their
longitudinal study that explored factors contributing to the retention of URM students in STEM, Chang and colleagues (2014) determined that URM STEM students who joined a professional club related to their major were 9.3 percentage points more likely to persist than students who did not affiliate with such groups.

The supportive networks of peers and faculty provided additional sources of social capital which appeared influential towards persistence for URM female STEM students (Stanton-Salazar, 2011). URM female STEM students offered high praise of their relationships with faculty. In particular, URM female STEM students assessed their faculty as being approachable, and accessible, as well as highly desiring them to succeed. Students also lauded faculty for the personal interest they took in their lives, both personal and professional. Faculty who took a more holistic view towards the development of URM female STEM students empowered their students to project forward and envision themselves as future STEM professionals (Museus & Neville, 2012; Nguyen, 2015). Only two percent of URM female STEM students in this study indicated that their faculty were not academically encouraging, and this was consistent across college types. The validation that students receive from faculty may “reinforce self-worth and value in educational environments that may help students remain resilient despite microaggressions and assaults on their social identity” (Hurtado, Ruiz Alvarado & Guillermo-Wann, 2015, p. 74). The culture within these liberal arts colleges, as well as the more intimate size of these institutions, allowed students to have multiple interactions (teacher, advisor, lab supervisor, mentor) with specific faculty members over time. These multiple points of contact fostered avenues for deepened trust to develop between faculty and student, while opening doors for students to access and acquire an array of beneficial resources aiding their development as future STEM professionals (Coleman, 1988; Stanton-Salazar, 2011; Museus & Neville, 2012).
Many of the URM female STEM students who were interviewed indicated that during their second year of STEM study they experienced a low in their academic self-confidence. Also during the second year of STEM study, URM female STEM students indicated a statistically significant difference in their sense of academic belonging in STEM when compared to their non-URM counterparts, a comparable difference that was not evident between these student groups in their first year of study. Fostering environments in which URM female STEM students can develop a greater sense of belonging within the STEM academic community appears vital to student success. In this study, a sense of belonging in the academic community affected the acquisition of STEM related cultural capital during college and well as the development of URM female students’ science identity, each necessary ingredients for persistence. Although the agency to persist appears to come from a multitude of sources, affirming relationships with faculty seem essential in helping students overcome obstacles while supporting student success. “Whenever faculty members engage with a student, they have an opportunity to impact persistence” (Foltz et al., 2014, p. 5). The cultures within these campuses promoted relationships between faculty and students that went well beyond the typical hierarchal faculty/student association. Students’ relationships with faculty appeared to have affected URM female students’ commitment to STEM (Komarraju, Musulkin & Bhattacharya, 2010; Grandy, 1998; Nguyen, 2015).

**Forming Identities to Sustain STEM Persistence**

In prior research, identity theory has been used as a lens to reveal a deeper understanding of women who persist in science (Brickhouse, 2001; Ceglie, 2011; Carlone & Johnson, 2007; Aschbacher Li & Roth, 2010). In this study, Carlone and Johnson’s (2007) conceptual model of Science Identity for women of colour was
explored through examining the domains of performance, competence and recognition by others, and by creating a Science Identity index score for each URM female STEM student in this study based on a quantification of those domains. Additionally, a more holistic understanding of a URM female STEM student’s Science Identity was explored through the interview process. Since Science Identity is not seen as a static measure and likely changes over time based upon students’ lived experiences and interactions with the environment (Proshansky, Fabian & Kaminoff, 1983; Aschbacher et al., 2010), this study sought to understand the different aspects of the college experience that may affect the development of a URM female STEM student’s Science Identity during her time at college.

In this study, as determined through a regression analysis, the leading indicator that predicted Science Identity was the social capital a URM female STEM student acquired during college. For many URM female STEM students, their peers, faculty, advisors and mentors operated as “identity agents”, further solidifying their sense of self as it related to their identity within the scientific realm (Schachter & Marshall, 2010). The social networks and affirmation received from within their STEM communities and cultural enclaves appear to have influenced the positive development of a science identity for women of colour.

For a URM female STEM student, the shaping of identity was not only influenced through interactions with others within her STEM communities, but was also influenced by her perception of how others saw her, even those outside the STEM community (Ceglie, 2011; Gee, 2000). In this study, many URM female STEM students enjoyed the accolades and prestige that came with majoring in a STEM discipline, particularly as those outside this academic field perceived STEM as a rigorous and challenging field of study. As Seymour and Hewitt (1997) note, “the respect this brings
from peers or outsiders can become a reward for persistence in and of itself” (p. 104). The symbolic capital acquired through identification as a STEM student may have allowed URM female STEM students to not only gain certain resources and personal agency to combat the otherwise discouraging aspects of their STEM educational programs, but also to align themselves with those who are moving towards futures as STEM professionals (Trueba, 2002; Bourdieu, 1984). This result also supports Carlone and Johnson’s (2007) assertion that the most dominant sphere of influence within their model of science identity for women of colour is the recognition component, the essence that you are recognised by others as someone possessing scientific talent and skills.

For URM female STEM students in this study, recognition by others however was not just limited to the affirmation received from peers, faculty and advisors within the context of academically influential social networks. It also included the recognition received by others from their home communities as some URM female STEM students aspired to act as cultural brokers, passing along essential information so that others in their families or communities would have the knowledge of one day pursuing a college path in general, and a STEM pathway more specifically (Cooper, 2014). Assuming the role as a cultural broker for a future generation of STEM professionals may have positively influenced and further solidified how a young woman of colour identifies and places herself with a STEM context.

Another significant predictor of science identity formation for URM female STEM students was the positive perception of their campus’ racial climate. Weidman’s college impact models (1989, 2001, 2006) confirm the unique socialisation processes that occur in students’ lives throughout their college experience, which in turn may more specifically impact the development of URM female STEM students’ science
With the exception of a very small handful of students, the vast majority of students in this study resided on campus, and the relationship to the campus environment, particularly their experience of the racial climate on campus, appears to have affected a URM female STEM student’s development of her science identity. “In effect, the subjective sense of self is defined and expressed not simply by one’s relationship to other people, but also by one’s relationships to the various physical settings that define and structure day-to-day life” (Proshansky et al., 1983, p. 58).

Another specific aspect of Carlone and Johnson’s (2007) model of science identity is the competence domain, the ability to know and understand a body of science related knowledge. As a reflection of their competence, all of the URM female STEM students who were interviewed planned to pursue a STEM related path upon graduation, with most hoping to pursue post-graduate study in science or the medical fields. For many of the women, aligning with a future STEM pathway was also fuelled by a passion and desire that those from their home based communities would benefit from their experience and education. Similarly, as noted by Carlone and Johnson (2007, p. 1209), almost all of their study participants aligned their science ambition with their altruistic career goals. For the URM female STEM students in this study, their science ambition and identity provided agency for persistence with the hope of paving the way for future benefit for their families.

Several URM female STEM students also looked to role models as influential in helping them more tangibly construct their own science identities. These role models offered a form of relational capital in which URM female STEM students used to further enhance their own sense of science identity. The impact of role models is discussed in greater detail in the next section.
Other Influential Relationships that Affirm Persistence

The literature is replete with examples of how parents have played a significant role in encouraging their daughters in their academic endeavours in STEM (Grandy, 1998; Russell & Atwater, 2005, Ellington, 2006). Consistent with other research, URM female STEM students in this study indicated receiving high levels of academic encouragement from their parents. Additionally, there was not a significant difference between URM and non-URM female STEM students’ perception on this measure of parental support. It appears that parental encouragement is a key to persistence in STEM for all students. Although there were positive correlations between the perceived levels of academic support a URM female STEM student in this study received and her parents’ prior level of education as well as her family’s SES, the interviews revealed that the type of encouragement URM female STEM students received from their parents was primarily in the form of emotional support and educational expectations. URM female STEM students were generous in their praise of the support they received from their families. As gleaned from the interviews, URM female STEM student shared how their mothers, in particular, played a critical role in providing the support they needed to press on, a result confirmed in other studies (Brainard & Carlin, 1998; Cabrera & Padilla, 2004; Hanson, 2007). The multitude of social media platforms currently available also allowed URM female STEM students to communicate with their mothers, some daily, and in real time when a need for affirmation arose. The mother – daughter relationship provided a deep well from which many URM female students drew the necessary emotional resources in order to persevere and persist.

While there did not appear to be a significant difference in the academic support URM and non-URM female STEM students received from parents, when comparing first-generation URM female STEM students \(n=26\) to non-first generation URM
female STEM students \((n=66)\), a significant gap in perception of academic support from parents was noted. Although only 10 of the 30 URM female STEM students interviewed in this study were first-generation college students, a clear pattern emerged in which parents were unable to fully empathise with their daughter’s concerns as they themselves were without first-hand knowledge of the college experience. However, first-generation students were not without opportunity to receive encouragement from meaningful adults in their lives. Over 40% of the first-generation URM female STEM students in this study indicated that they had a professional mentor in their lives, and the relationship with these mentors may have provided the emotional and academically inspired support necessary for persistence, support in some cases lacking from parents.

Several of the colleges in this study hosted campus-based and national programs in which first-generation URM female STEM students participated, programs geared towards improving the retention and academic experiences of students who may have come from disadvantaged backgrounds. At Cahill University, the Success in Engineering Initiative provided participants with professional mentors from STEM based industries, and first-generation students in the Posse Scholars program were assigned a mentor who often shared common background characteristics with the student. Both of the women’s colleges offered first-generation support networks for students whose parents did not attend college. Aimed at students from under-resourced backgrounds, including those who are first-generation, Whitt College’s Achievement Scholars Program assigned participating students a mentor as well as a research advisor as part of this program. Hayden University sponsored the nationally based LEAD program whose emphasis was on improving the retention of first-generation students. While each program delivered unique offerings, a hallmark of the mentoring relationships provided through these efforts appears to be a sense of holistic care.
coupled with personal affirmation of the student. The level of personal attention first-generation URM female STEM students received from their mentors may have worked towards filling the gap in the encouragement needed to persist, encouragement that may have more naturally come from families whose parents had attended college.

Summary

In this study, Weidman's (2006) model of undergraduate socialisation served as a useful frame in which to explore the impact of various institutional settings and contexts on student persistence. Across the different college types, and with the exception of racial climate, the assessment of URM female STEM students towards their higher education experience was surprisingly similar. In their case study at an all-female HBCU, Perna and her team (2009) highlighted the positive institutional attributes that contributed to the success of URM female STEM students: small class sizes, accessibility of faculty, faculty encouragement, peer support, research opportunities, academic support services and STEM specific programs to name a few. However, these institutional features are not exclusive to minority serving institutions. Each of the colleges in this study (PWI and HBCU) embodied these specific institutional characteristics and displayed an environment in which URM female STEM students could appropriate the necessary resources towards aiding their success.

“Perhaps more important than the type of colleges or universities URMs in STEM attend are the experiences they have at those institutions” (Museus & Liverman, 2010, p 18). Thomas (2001) also suggests that through their missional values and institutional practices, colleges may possess a habitus which influences student persistence. In this study, institutional habitus that guided persistence was reflected in the way each of the colleges placed a high value on diversity and displayed a commitment to student success, especially towards students who had come from disadvantaged backgrounds.
Within the context of these five private liberal arts colleges Tierney’s (1999) concept of cultural integrity, Stanton-Salazar’s (2011) theory of institutional agents and Yosso’s (2005) notions surrounding community cultural wealth provided useful lenses through which to focus on and wrestle with the complexities surrounding the lived experiences of female URM STEM students, particularly in investigating the sources and acquisition of education enhancing capital that influenced persistence. In tandem with these theoretical tenets, exploring measures of ethnic identity and operationalising indicators of cultural and social capital were useful in order to quantitatively test and validate Tierney’s (1999) and Stanton-Salazar’s (2011) theoretical concepts. While these frameworks already engender significant support in the literature, this study was able to offer both quantitative and qualitative validation of these theories, and adds to the current body of literature.

The conceptual model (see Figure 4) developed in this study relied upon theories of identity, college impact models, and theories of cultural and social capital and became a source from which the research questions in this study emerged. While this model intended to represent the multidimensional factors considered as influential towards the persistence of URM women in STEM fields of study set within the context of a liberal arts college setting, it is by no means exhaustive of the factors that may indeed impact persistence. In this study, several pre-college factors appear influential toward persistence for URM female STEM students. They include completion of high school calculus, participation in a college preparation program, affirming relationships with high school maths and/or science teachers, assistance with college and financial aid applications from guidance counsellors or key high school personnel, high educational expectation from parents, and a high school GPA above a B+ average. Figure 11 highlights the college experiences that consistently emerged as influential in the lives of
URM female STEM students who persisted at each of the liberal arts colleges examined in this study. These attributes were commonly observed in those URM female STEM students who persisted, regardless of whether they attended a coeducational college, women’s college or HBCU, and may serve useful for future models (Museus & Liverman, 2010). Additionally, future models perhaps should address more explicitly the impact of racial climate as this appeared to be the most differentiating aspect of the college experience of URM female STEM students studying and pursuing STEM in the context of a liberal arts college environment.

**Figure 11.** Liberal arts college experiences that contribute to persistence for URM female STEM students at selected liberal arts colleges.
The next and final chapter of this thesis offers a summary of key findings with recommendations for future study or policy considerations for liberal arts college administrators.
Chapter 7: Conclusion

The purpose of this study was to gain a better understanding of how the organisational environment and social practices experienced at different types of liberal arts colleges affected the persistence of underrepresented racial minority women in STEM. While prior research supports the notion that liberal arts colleges are effective producers of STEM graduates (Cech, 1999), the literature on how different types of liberal arts institutions actually support URM female STEM students in their personal and academic endeavours along a STEM pathway is slim in nature. Drawing on the theoretical frameworks of identity theory, a college socialisation impact model, and theories of cultural and social capital, this study offered a comparative analysis of the unique and complementary contributions made by women’s colleges, historically Black colleges and universities (HBCUs) and coeducational liberal arts colleges towards aiding the persistence of underrepresented racial minority (URM) women in STEM. While, prior research affirms the important role that HBCUs play in producing URM STEM graduates (Perna et al., 2009; Gasman, 2011), little research has been carried out on the role that liberal arts colleges, and more specifically women’s colleges, play in building and sustaining the confidence and persistence for URM women to succeed in the competitive STEM higher education environment.

This study, however, did not deal directly with issues related to attrition, but instead focused on those URM women who were exemplars of persistence in STEM, and who attended colleges that were already known to successfully produce female STEM graduates. The following is a summary of key findings with recommendations for future study or policy considerations for liberal arts college administrators.
1) High level secondary mathematics preparation and mathematics support are essential for success in STEM.

Although URM female STEM students were generally less academically prepared for college, they completed the highest levels of secondary mathematics at rates almost equal to their non-URM (White/Asian) female STEM counterparts. For students who lacked confidence or mathematics skills upon college entry, many of the colleges offered mathematics support groups for high-ability students from under-resourced high schools to guide STEM persistence. These programs not only assisted students who needed remediation, but also allowed students to form cultural enclaves with other students from similar backgrounds in order to ensure success in STEM classes through increasing a sense of belonging and enhancing social networks. A greater emphasis needs to be placed on offering rigorous mathematics curricula across secondary schools, particularly those from under-resourced school districts as this is critical for URM female STEM students to develop the academic skill set for success in STEM at college. Secondary schools may consider developing mathematics specific bridging programs for promising URM female students. Additionally, colleges may consider ways in which to make mathematics remediation programs more accessible and attractive for URM female students who may lack the skills but possess the desire to pursue STEM.

2) Adequate financial aid for college attendance paves a way to persistence.

URM female STEM students were more satisfied than non-URM female STEM students with their college financial aid packages and for many URM female STEM students, the amount of financial aid they received determined which college they attended. Many URM female STEM students received guidance outside their families
on the sources of financial aid and the application process for that aid. Increasing opportunities for URM students and their families to understand the affordability of colleges that guarantee to meet a high percentage of a student’s financial need, through improved communication with college financial aid offices and high school college counselling offices or college preparation programs, may pave a wider path for URM female STEM students in STEM.

3) College Preparation programs help URM female STEM students fill the gap in knowledge about the college-going process and access to financial aid resources. Many successful URM female STEM students in this study participated in college preparation programs (external to their high schools) that guided them through the U.S. college application process and provided ongoing support in the transition process to college. These young women often attended under-resourced high schools or were the first in their family to attend university. The literature on college preparation programs, especially those with a STEM focus, is limited and may be a worthy area of future study as the impact of these programs appears significant for students from disadvantaged backgrounds choosing a STEM path at college. Additionally, college admissions offices might consider extending their recruitment strategies to include visits to college preparation programs in order to broaden their impact of recruiting talented URM female students in STEM.

4) URM female STEM students who persist in STEM, start in STEM.

For the women in this study, the choice to pursue STEM was primarily decided upon in high school (though in many U.S. colleges and universities, students do not need to “declare” their major until the end of second year). For URM females, the resolve to pursue STEM was often influenced through a significant relationship with a
high school teacher who recognised and encouraged their talent in mathematics and/or science. In this study (n=447), only 4% of students (both URM and non-URM) switched into STEM after first declaring a non-STEM major. The impact of teachers appears critical in shaping the science identities of URM female STEM students. While the professional development of secondary teachers is often focused on content knowledge and effective teaching practices, more research may be warranted on the ways that high school teachers may influence minority female students towards a STEM pathway.

5) GPA and grades in STEM are a source of discouragement and may lead URM female STEM students to seriously consider leaving STEM.

URM female STEM students were almost twice as likely to indicate that they seriously thought of quitting college and leaving STEM when compared to their non-URM counterparts, and this was correlated to GPA (grade point average). Students appeared to gauge their self-concept of whether or not they were a successful STEM student largely on the external validation offered through their GPA. However, with the help of faculty, mentors and peers, URM female students were able to “redefine” success and achievement apart from their grades and re-shift their perspective, leading to both heightened resilience and persistence. Colleges may consider offering workshops for advisors on how to more effectively counsel students in regards to the relationship that students place on grades and the resulting impact on self-concept and personal validation. Additionally, colleges may also consider investigating the appropriateness of instituting “shadow grading” for students in their first semester of college; a grading structure recently adopted at several selective liberal arts colleges. Shadow grading is a system in which students do not receive actual letter/numeric grades in their first semester of college, but instead receive a “satisfactory/not satisfactory” mark (The Prospect, 2016). The adoption of a grading system such as this
may encourage URM female STEM students to explore STEM related subjects that may interest them without the added pressure of achieving a certain GPA. As well, a grading system similar to this might also help young women who may have otherwise abandoned STEM after their first semester of college due to an underwhelming GPA, continue on a STEM pathway into second semester and beyond.

6) College programs provide access for the acquisition of education enhancing capital and offer key sources of academic and social support that aid persistence.

The liberal arts colleges in this study were committed to the success of URM students, and provided many programs to assist and support students in STEM. Each of the colleges also appeared committed to the ideals of a diverse and inclusive community through providing resources, programs and cultural spaces for URM students to further explore their racial and cultural heritage. These programs, both cultural and academic, were often led by enthusiastic directors who were passionate about the success of their students. Some programs were geared to all students; some programs were focused specifically on students from under-resourced backgrounds and/or minority students. A few noteworthy programs are listed below.

a. STEM Scholars Programs – provided mentoring and research opportunities for minority and students from disadvantaged backgrounds.

b. STEM related success programs – provided additional help in STEM related mathematics tutoring, peer tutoring, faculty mentoring and access to research and internships for minority and students from disadvantaged backgrounds.

c. First-generation Network – provided extra supports for students who were the first in their families to attend university.

d. URM Peer Mentoring in STEM.
e. Summer Research Programs- stipend (and sometimes housing) provided to students to embark on summer research projects.

f. Undergraduate Research Symposiums/ Funding to present research at conferences – Forums for students to present their research on and off campus.

g. Ethnic STEM student groups, i.e. National Society of Black Engineers.

The colleges in this study offered a plethora of programs aimed at lifting achievement, persistence, community and belonging. URM female STEM students who persist are highly engaged on campus, even more so than their non-URM counterparts. Active involvement in co-curricular and STEM related extracurricular activities are essential aspects of college life for URM female STEM students who persist in STEM. In particular, URM female STEM students exhibited statistically higher participation rates than non-URM female STEM students in attending diversity events, volunteering and having a professional mentor. Approximately two-thirds of URM female STEM students who persisted participated in research. The titles of the retention style programs offered by the colleges in this study included words such as “success” or “scholar” in their names. Using titles that embrace concepts of success and not underachievement may make these programs more attractive to those considering participation. Colleges may also want to consider how they disseminate and market these various academic and non-academic programs to students. Visible campaigns to promote these programs may encourage URM female STEM students at the very beginning of their college experience to invest in research activities, STEM peer mentoring, cultural groups or others programs that have proven effective in retaining young promising women in STEM.
7) URM female STEM students’ commitment to their ethnic identity and finding similar peers to struggle with help women to form strong social networks that encourage persistence in STEM.

The women in this study developed powerful bonds over a common appreciation of the struggle they each faced as students of colour in pursuing and persisting in STEM. Through gathering together in these cultural enclaves, minority students communally developed the navigational and aspirational capital required to direct the course of their education while resisting the subtle forms of racism found on their campuses. Through recognising the impact that these cultural enclaves have on persistence for URM female STEM students, college administrators may consider how they can offer increased resources, time and space that encourage the formation and continuity of these types of groups for underrepresented racial minority women in STEM. Ethnic Identity commitment and a student’s belief that her college had effective diversity programs supported by the university were also strong predictors for acquiring the educational enhancing capital to persist in STEM.

8) Altruistic goals of hoping to effect positive change in their communities or in their families inspire many URM female STEM students to persist.

Many of the women in this study came from homes where they were the first to attend college. Their desire to become role models for their communities and for their families provided agency that motivated persistence, even in the face of opposition. College educators can tap into that internal altruistic drive which motivates many URM female STEM students through providing STEM specific opportunities geared at community development and cross-cultural research projects.
9) Faculty relationships are key for persistence.

URM female STEM students consistently praised faculty for their accessibility, availability outside the classroom, guidance, mentoring and personal care. Faculty who took a personal interest in students and demonstrated care in not only their academic progress but also in their overall well-being made a significant difference in the lives of URM female STEM students who persisted. Liberal arts colleges by their nature and mission, often maintain a greater focus on teaching when compared to research universities. The environment within liberal arts colleges may more naturally foster deeper faculty-student connections. Considering the impact that non-cognitive relational factors may have towards the success of URM female STEM students, college administrators may consider offering professional development workshops to faculty on proven effective communication practices within student/faculty relationships that encourage persistence for URM female students in STEM.

10) Families provide an important source of emotional encouragement.

Many URM female STEM students in this study had close relationships with their families, especially their mothers, and many received affirmation to persist. However, while URM female STEM students may have received emotional encouragement from their parents, the academic encouragement necessary for persistence came primarily from peers and from faculty; so having strong relationships with both peers and faculty on campus was also essential. Some colleges offer wellness programs and “first-year” experience programs designed at helping students make the transition to living at college and away from home. While these programs are often aimed at helping students develop independence, a key strategy could also focus on encouraging students in maintaining a positive connection to their parents and home.
communities. Additionally, training for academic advisors could focus on ways to counsel students on maintaining a healthy emotional connection with their families.

11) For URM female STEM students who persist, their Science Identity during the college years is shaped by the influence of the racial climate on campus, the social capital acquired from faculty, mentors, advisors and peers, as well as the student’s sense of academic belonging in the STEM.

The formation of science identity appears affected by the environment in which it is shaped. Recognition from others was also impactful towards affirming the identity of URM female students in STEM. While this study only assessed a measure of science identity at one point in time, future research may further elucidate the role that environment plays in the formation and malleability of science identity over a longer course of time.

12) URM female STEM students hold significantly lower perceptions of campus racial climate than do non-URM female STEM students.

The assessment of racial climate was the predominant factor that significantly differentiated the responses between URM and non-URM female STEM student across all campus types, and between URM STEM students based on attendance at a PWI or HBCU. While the majority of URM female STEM students did not indicate a negative perception of their campuses’ racial climate, non-URM Female STEM students held significantly higher perceptions of campus racial climate than did URM female STEM students. In particular, some URM female STEM students indicated experiencing lowered expectations from other students, as well as hearing subtle racist remarks from classmates. URM female STEM students developed defensive strategies when classmates doubted their work. However, when dealing with subtle derogatory comments, URM female STEM students tended to downplay these racially charged
remarks believing that comments were more based in ignorance than a desire to harm. Racial climate is an important topic of study as it affects students’ sense of belonging which in turn may affect persistence. Colleges may consider offering awareness training for faculty and staff in understanding the struggles URM students face in the academic setting with the goal of planning strategies to create more inclusive and welcoming communities within classrooms and campus spaces. Racial climate is a multifaceted and multilayered topic, and future comparative research on the complexities of racial climate at different types of higher education institutions may further illuminate how campus culture, campus climate and structural diversity may affect student success in STEM for underrepresented racial minorities.

The path to acquiring the education enhancing capital necessary for persistence in a college STEM environment begins early in a student’s schooling and continues throughout one’s education. This study focused on underrepresented racial minority undergraduate women in STEM, and the environments and experiences that shaped their persistence within a liberal arts college setting. Much can be learned through studying students who are exemplars of persistence as well as the colleges that provide a myriad of resources aimed at aiding degree attainment. Although it may be an uphill battle for minority women to develop the social networks and acquire the capital necessary for persistence in STEM, the URM female STEM students in this study demonstrated that obstacles can be overcome and deficits in capital can be offset, paving a way towards educational success.

Over the next few decades, the evolving shift in America’s demographics will certainly impact the setting within America’s colleges and universities on whose shoulders lie the responsibility to train the next generation of STEM professionals. Underrepresented racial minority women offer the potential to expand the current
STEM talent pool both now and into the future. Building on a foundation of justice and equity, it is imperative that college administrators take seriously the call to support and understand the learning needs of URM women who aspire to pursue a career pathway in STEM. Based on the results of this study, this chapter has highlighted key findings with recommendations for future study or policy considerations for liberal arts college administrators. While the literature on the intersection of gender and race in STEM is limited in nature, this study contributes to this body of knowledge through offering a depth of insight towards understanding the background, resources, relationships and experiences that empowered URM women, specifically within a liberal arts college context, towards degree persistence in STEM. Building on such success would not only be of benefit to the young women themselves, but would represent a significant step forward in equity in U.S. higher education and society.
References


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APPENDIX A
Survey Instrument

Survey Introduction:

You are invited to participate in a study which aims to offer a comparative analysis of the contributions made by different types of liberal arts colleges towards promoting persistence for women in STEM (science, technology, engineering, mathematics).

If you participate in completing the survey/questionnaire, you will be given a variety of prompts in which you will be asked to check a box which best indicates your response.

The prompts cover your secondary school background, your family and ethnic background, your college experience, your interest and involvement in STEM (science, technology, engineering or mathematics) and perceptions of racial discrimination in your campus experience.

While there is low risk in taking the survey, some of the topics may make some students feel uncomfortable. Therefore, for any reason, you are free to skip any questions or end the survey at any time. There are no open ended questions and it should take approximately 10-15 minutes to complete the survey.

Participation or non-participation will have no bearing on one’s grade or standing at your college.

Being in this study is completely voluntary and you are not under any obligation to consent to complete the questionnaire/survey. If you do consent you can withdraw at any time. Submitting a completed questionnaire/survey is an indication of your consent to participate in the study. You can withdraw any time prior to submitting your completed questionnaire/survey. Once you have submitted your questionnaire/survey, your responses cannot be withdrawn.

This survey is being conducted with the help of Survey Monkey, a company not affiliated with your college. Your responses are anonymous. All aspects of the study, including results, will be strictly confidential. The privacy and security policies of Survey Monkey can be found at https://www.surveymonkey.com/mp/policy/security/.

We anticipate that your participation in this survey presents no more risk than would be expected taking an online survey. A report of the study may be submitted for publication, but individual participants will not be identifiable in such a report.

By selecting the "next" button, you consent to participate in this study.
**Section I Background**

1. **What is your year in College**
   - □ First  □ Sophomore  □ Junior  □ Senior  Other:___________________

2. **a. Major:**  
   **b. Year of college when I declared this major:**

3. **If you switched your major, what was your previous concentration:**

4. **What gender best describes you:**  
   □ Female  □ Male

5. **What ethnicity best describes you. Please tick all that apply**
   - □ Asian or Asian American, including Chinese, Japanese, and others
   - □ Black or African American
   - □ Hispanic or Latino, including Mexican American, Central American, and others
   - □ White, Caucasian, Anglo, European American; not Hispanic
   - □ American Indian/Native American
   - □ Mixed; Parents are from two different groups
   - Other: ________________________________

6. **What ethnicity best describes your mother.**
   - □ Asian or Asian American, including Chinese, Japanese, and others
   - □ Black or African American
   - □ Hispanic or Latino, including Mexican American, Central American, and others
   - □ White, Caucasian, Anglo, European American; not Hispanic
   - □ American Indian/Native American
   - □ Mixed
   - Other: ________________________________

7. **What ethnicity best describes your father.**
   - □ Asian or Asian American, including Chinese, Japanese, and others
   - □ Black or African American
   - □ Hispanic or Latino, including Mexican American, Central American, and others
   - □ White, Caucasian, Anglo, European American; not Hispanic
   - □ American Indian/Native American
   - □ Mixed
   - Other: ________________________________

8. **a. My mother’s occupation:**  
   **b. My father’s occupation:**

9. **My high school location is:**  
   □ Urban  □ Suburban  □ Rural
10. The high school I attended is (please tick ALL that apply):
   □ Public   □ Private   □ Catholic/Religious   □ Co-Educational   □ All-Girls HS

11. In my high school, the percentage of seniors who went to college is:
   □ 90-100%   □ 75-90%   □ 50-75%   □ 25-50%  □ less than 25%  □ don’t know

12. In my high school, African-Americans, Blacks and Hispanic students in total accounted for what fraction of the student body:
   □ More than half  □ About a 1/3 to 1/2  □ About 1/4 to 1/3  □ less than 1/3  □ less than 1/10  □ don’t know

13. In my high school, the educational expectation for most of the student body was:
   □ to complete H.S. degree  □ Some college  □ Finish College  □ Earn advanced degree

14. In my high school peer group, my friends thought it was important to (please tick ALL that apply):
   □ get good grades  □ study  □ finish high school  □ continue education past high school
   □ complete college degree  □ play sport  □ make friends  □ enjoy life/have fun

15. Who encouraged you to attend college (tick ALL that apply):
   □ parents  □ siblings  □ other family  □ friends  □ teachers  □ counselor  □ coach
   □ other: __________________________

16. My high school or outside educational support program provided help in the college application process with (please tick ALL that apply):
   □ application  □ SAT/ACT test prep  □ essays  □ financial aid application
   □ college visits  □ final college decision

17. Prior to college, I attended a science, math or engineering enrichment program:
   □ No  □ Yes  If yes, what program(s): __________________________

18. During High School, I completed the following classes (please tick ALL that apply):
   □ AP Calculus  □ Calculus  □ PreCalculus  □ AP Biology  □ Biology  □ AP Chemistry
   □ Chemistry  □ AP Physics  □ Physics  □ AP Computer Science  □ Computer Science  □ AP Environmental Science  □ Earth Science  □ AP Statistics  □ Statistics  □ other
   □ math/science: __________________________

19. What was your HS GPA?
   □ 3.7-4.0 (A/A-)  □ 3.3-3.6 (B+/A-)  □ 3.0-3.2 (B)
   □ 2.7-2.9 (B-)  □ 2.3-2.6 (C+/B-)  □ Don’t remember

20. What is your College GPA?

21. Did you take the SAT? □ Yes  □ No
   If yes, what was your SAT Math score: _______

22. Did you take the ACT? □ Yes  □ No
   If yes, what was your ACT Math score: _______
23. When I started college my mother’s educational expectations for me were:
- □ earn bachelor’s degree
- □ earn advanced degree
- □ other _______________________

24. When I started college my father’s educational expectations for me were:
- □ earn bachelor’s degree
- □ earn advanced degree
- □ other _______________________

25. What is the highest level of school your mother completed or the highest degree she received?
- □ Less than High School
- □ High School (or GED)
- □ Some College
- □ 2-yr College Degree
- □ 4-yr College Degree
- □ Graduate Degree

26. What is the highest level of school your father completed or the highest degree he received?
- □ Less than High School
- □ High School (or GED)
- □ Some College
- □ 2-yr College Degree
- □ 4-yr College Degree
- □ Graduate Degree

27. My family’s annual combined income is about:
- □ less than $60K
- □ between $60K-$80K
- □ between $80K-$100K
- □ between $100K-$150K
- □ > $150K
- □ don’t know

28. During my high school years, my parents were involved in my school through the following ways:
- □ attended parent/teacher nights
- □ attended school PTA meeting
- □ attended school/class event
- □ volunteered at school
- □ organized tutoring for me
- □ helped me with my homework

### Section II College Experience

29. While in college I have participated in (please tick ALL that apply):
- □ Diversity Events/Clubs
- □ Research Opportunities
- □ Internships
- □ Academic Support/Tutoring
- □ Volunteering
- □ Peer Tutoring
- □ Professional Clubs (Society of Women Engineers, etc)
- □ Professional Mentoring

As you reflect on your college experience, please check the box which best describes your response:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>30. Due to my ethnic/racial background I have felt alienated in the campus environment</td>
<td></td>
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<tr>
<td>31. Due to my ethnic/racial background I have felt alienated in my math/science classes</td>
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<td>32. At times, I seriously thought about quitting college</td>
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<td>33. At times, I seriously thought about leaving my math/science related major</td>
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<td>34. My science/math classes are too competitive</td>
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<tr>
<td>35. I have had to persevere despite both individual and institutional discrimination</td>
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<tr>
<td></td>
<td>Statement</td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Neutral</td>
<td>Disagree</td>
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<tr>
<td>36</td>
<td>My campus takes issues of diversity seriously and has effective programs</td>
<td></td>
<td></td>
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<tr>
<td>37</td>
<td>My college is preparing me well for my chosen career path</td>
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<tr>
<td>38</td>
<td>I have the skills to know how to get administrative questions answered (financial aid forms, internship applications, etc.)</td>
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<tr>
<td>39</td>
<td>My parents are a source of academic encouragement</td>
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<tr>
<td>40</td>
<td>My classmates are a source of academic encouragement</td>
<td></td>
<td></td>
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<tr>
<td>41</td>
<td>My teachers are a source of academic encouragement</td>
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<tr>
<td>42</td>
<td>My advisor/mentor is a source of academic encouragement</td>
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<tr>
<td>43</td>
<td>My college has provided adequate financial aid</td>
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<tr>
<td>44</td>
<td>If I am falling behind in a class, I know exactly where to go to get help.</td>
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<tr>
<td>45</td>
<td>My college's career advice and counselling provides me with adequate knowledge and preparation for either a job or grad school success</td>
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</tr>
<tr>
<td>46</td>
<td>My academic preparation is providing me with the knowledge and skills necessary for a successful math/science based career</td>
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</tr>
<tr>
<td>47</td>
<td>My classmates recognize me as someone with talent and potential in math or science</td>
<td></td>
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<tr>
<td>48</td>
<td>My teachers recognize me as someone with talent and potential in math or science</td>
<td></td>
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</tr>
<tr>
<td>49</td>
<td>Since high school I am now better prepared to handle personal and academic setbacks</td>
<td></td>
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<td></td>
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<tr>
<td>50</td>
<td>I have formed relationships of mutual trust with teachers/advisors which will help me to finish college successfully</td>
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</tr>
<tr>
<td>51</td>
<td>At times, I have felt that my math/science teachers underestimated my academic abilities due to what I would consider racial discrimination</td>
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<tr>
<td>52</td>
<td>In my first year I felt a sense of belonging in my academic community</td>
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<tr>
<td>53</td>
<td>In my sophomore year, I felt a sense of belonging in my academic community</td>
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<tr>
<td>54</td>
<td>In my junior year, I felt a sense of belonging in my academic community</td>
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</tbody>
</table>
Section III (R. Roberts et al., 1999).
Multi-group Ethnic Identity Measure (MEIM)

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>I have spent time trying to find out more about my ethnic group, such as its history, traditions, and customs.</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>56</td>
<td>I have spent time trying to find out more about my ethnic group, such as its history, traditions, and customs.</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>I am active in organizations or social groups that include mostly members of my own ethnic group.</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>I have a clear sense of my ethnic background and what it means for me.</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>I think a lot about how my life will be affected by my ethnic group membership.</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>I am happy that I am a member of the group I belong to.</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>I have a strong sense of belonging to my own ethnic group.</td>
<td></td>
</tr>
<tr>
<td>62</td>
<td>I understand pretty well what my ethnic group membership means to me.</td>
<td></td>
</tr>
<tr>
<td>63</td>
<td>In order to learn more about my ethnic background, I have often talked to other people about my ethnic group.</td>
<td></td>
</tr>
<tr>
<td>64</td>
<td>I have a lot of pride in my ethnic group.</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>I participate in cultural practices of my own group, such as special food, music, or customs.</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>I feel a strong attachment towards my own ethnic group.</td>
<td></td>
</tr>
<tr>
<td>67</td>
<td>I feel good about my cultural or ethnic background.</td>
<td></td>
</tr>
</tbody>
</table>


Below are a series of statements that are more or less true (or more or less false) descriptions of you. Please use the following eight-point response scale to indicate how true (or false) each item is as a description of you. Respond to the items as you now feel even if you felt differently at some other time in your life.

1. Definitely False
2. False
3. Mostly False
4. More False Than True
5. More True Than False
6. Mostly True
7. True Definitely
8. True
<table>
<thead>
<tr>
<th></th>
<th>I find many mathematical problems interesting and challenging.</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>I am never able to think up answers to problems that haven’t already been figured out.</td>
</tr>
<tr>
<td>69</td>
<td>I have hesitated to take courses that involve mathematics</td>
</tr>
<tr>
<td>70</td>
<td>I am good at combining ideas in ways that others have not tried.</td>
</tr>
<tr>
<td>71</td>
<td>I have generally done better in mathematics courses than other courses.</td>
</tr>
<tr>
<td>72</td>
<td>I wish I had more imagination and originality.</td>
</tr>
<tr>
<td>73</td>
<td>Mathematics makes me feel inadequate.</td>
</tr>
<tr>
<td>74</td>
<td>I enjoy working out new ways of solving problems.</td>
</tr>
<tr>
<td>75</td>
<td>I am quite good at mathematics</td>
</tr>
<tr>
<td>76</td>
<td>I am not much good at problem solving</td>
</tr>
<tr>
<td>77</td>
<td>I have trouble understanding anything that is based upon mathematics.</td>
</tr>
<tr>
<td>78</td>
<td>I have a lot of intellectual curiosity.</td>
</tr>
<tr>
<td>79</td>
<td>I have always done well in mathematics classes.</td>
</tr>
<tr>
<td>80</td>
<td>I am not very original in my ideas, thoughts, and actions</td>
</tr>
<tr>
<td>81</td>
<td>I never do well on tests that require mathematical reasoning.</td>
</tr>
<tr>
<td>82</td>
<td>I am an imaginative person.</td>
</tr>
<tr>
<td>83</td>
<td>At high school, my friends always came to me for help in mathematics.</td>
</tr>
<tr>
<td>84</td>
<td>I would have no interest in being an inventor.</td>
</tr>
<tr>
<td>85</td>
<td>I have never been very excited about mathematics.</td>
</tr>
<tr>
<td>86</td>
<td>I can often see better ways of doing routine tasks.</td>
</tr>
</tbody>
</table>
APPENDIX B
Semi-Structured Interview Protocol (adapted from Perna et al., 2009)

1. Tell me a little bit about yourself…..what is your major? And what year are you?

2. When did you decide to major in a STEM field? What do you think most motivated this decision?

3. What does your family think about your decision to major in your field? Your high school friends? College friends?

4. Why did you choose to come to “insert name of college”? Who helped you in making this decision? How much did you know about this institution, and alternatives? Any other motivation to attend this college?

5. Did your high school experience prepare you for your STEM major? If so, in what ways were you adequately prepared for the rigors of your STEM major? Are there any ways in which your preparation was lacking? If so, in what ways?

6. Are there aspects of your ethnic background/community that prepared you to begin your college experience? If so, in what ways?

7. Do aspects of your ethnic/cultural background inspire you as you pursue your STEM studies? If so, what might those be? At times, have you felt that your ethnic/cultural background clashed with your college culture? If so, in what ways and how did you handle it?

8. Can you tell me about your experience as a women of colour in your STEM major at “insert name of college”? What aspects are most positive? What have been your greatest challenges? (listen and prompt for…)
   a. School culture (diversity on campus)
   b. STEM Classroom culture (gender dynamics (coed), diversity within classroom)
   c. Faculty interaction, in and out of the classroom
   d. Peer interaction (with ethnically similar and ethnically diverse peers)
   e. Academic advising
   f. Course, lab, research experiences
   g. Social/Diversity clubs and organizations
   h. Academic clubs and organizations
   i. Internships/professional work experiences
   j. Recognition by others as a talented women in science
   k. Financial Aid

9. Tell me about the social networks (peer, faculty, and professional) that you have established during your time at “insert name of college”. Do they offer any value to you as a student and possible STEM professional? If so, how?

10. Do you have a mentor?
    a. Is he/she faculty or peer?
    b. How did this person come to be your mentor? Was he/she formally or informally assigned?
    c. How would you describe your relationship with your mentor? Does your relationship with your mentor affect your success at “insert name of college”? If so, in what ways?
11. What kinds of supports are there for you if you need academic help? If you are looking for an internship or research? If you are looking for some other kinds of experiences that will help you with your academic life? Have you used any of these supports? If so, how was your experience? Overall, how confident are you in initiating contact for support?

12. Would you say that your academic self-confidence has grown, stayed the same or diminished during your time as a student at “insert name of college”? How? Why? In what ways?

13. What kinds of support and encouragement do you receive from the people in your life? How involved have your parents been in your education? High School? College?

14. What are your educational and career goals? Do you feel that “insert name of college” is preparing you for a successful career in your field? How? Any weaknesses in this preparation?

15. You have made it past the midway point of your degree program in STEM. How do you think you got this far?

16. When you have those days when you feel you have “hit the wall”, who or what do you go to for support?

17. If you could change one thing to better promote the academic success of women of colour in STEM fields at “insert name of college”, what would it be?

18. Is there anything else that you would like to share that has not already been covered in this interview?
APPENDIX C
Email Invitation to Participate in Study

Are you majoring in a science or math related field? Would you be willing to take a 10-15 minute anonymous survey to be used for PhD research? Would you like to enter a drawing for a $100 Amazon gift card? At the completion of the survey you will be directed to a webpage to enter this drawing.

To access the survey, please click on the link: https://www.surveymonkey.com/s/XXXXXXXX

A bit of background: this research is being conducted by Deborah Tully and will form the basis for the degree of PhD in Education at The University of Sydney under the supervision of Dr. Anthony Welch and auxiliary supervisor Dr. Debra Hayes. This research is approved through XXXX College’s Office of Institutional Research and the XXXXX faculty collaborator for this project is Dr. XXXX XXXXXXX.

Overall, this study aims to offer a comparative analysis of the contributions made by different types of liberal arts colleges towards promoting persistence for women in STEM (science, technology, engineering, mathematics). While your participation in this study is appreciated and will contribute to an important area of research, we cannot and do not guarantee or promise that you will receive any direct benefit from the study. Also, there is minimal perceived risk in taking this survey as most topics discussed are common to the everyday life experience of students.

If you have any questions about this research, you may contact the supervisor for this project: Dr. Anthony Welch; Anthony.welch@sydney.edu.au or the researcher at dtul4703@uni.sydney.edu.au. To access more information on the researcher: http://fdp.edsw.usyd.edu.au/users/dtully.

If you have any concerns, you may also contact the Institutional Review Board at XXXX College: XXXX XXXXX, PhD. XXX Hall xxx (xxx) xxx-xxxx xxx@xxxx.edu
APPENDIX D
Participation Information Statement

Chief Investigator/Supervisor Name: Deborah Tully/Prof. Anthony Welch

Faculty of Education and Social Work
Room 405
Building A36
The University of Sydney
NSW 2006 Australia
Telephone: +61293516358
Email: dtul4703@uni.sydney.edu.au
Web: http://www.sydney.edu.au

The path to persistence for women of color in STEM: a contextualized multiple case-study of women’s colleges, historically Black colleges and universities, and coeducational liberal arts colleges in the United States

(1) What is the study about?
You are invited to participate in a study which aims to offer a comparative analysis of the contributions made by women’s colleges, HBCUs and coeducational liberal arts colleges towards promoting persistence for women of color in STEM with the hope of providing deeper insight into the potential contributions that these unique institutions can offer towards empowering women of color towards success and diversifying the STEM workforce.

(2) Who is carrying out the study?
The study is being conducted by Deborah Tully and will form the basis for the degree of PhD in Education at The University of Sydney under the supervision of Dr. Anthony Welch and auxiliary supervisor Dr. Debra Hayes.

(3) What does the study involve?
You may participate by completing a survey and/or by participating in an interview

If you participate in completing the anonymous survey/questionnaire, you will be given a variety of prompts in which you will be asked to check a box which best indicates your response. The prompts cover your secondary school background, your family background, your college experience, your interest and involvement in STEM (science, technology, engineering or mathematics) and your ethnic background. There are no open ended questions and it should take approximately 10-15 minutes to complete the survey. You are free to skip questions or end the survey at any time.

If you participate in an interview, similar topics as above will be discussed. Interviews will be audiotaped. Confidentiality will be assured. You will not be identified by name. A pseudonym will be assigned. No Data connecting your personal info with your pseudonym will be collected.

Interviews will be held in a convenient location set by the researcher and interviewee, at a time deemed acceptable to both.
(4) Are there any risks to participating in this study?

There is low risk involved as most topics discussed are common to the everyday life experience of students or faculty. However, some participants may find it uncomfortable to discuss aspects of their social backgrounds and/or the perception of racial discrimination. Participants are free to skip any survey or interview question or end the survey or end the interview at any time.

(5) How much time will the study take? Questionnaires: 10-15 minutes; Interviews: 30-60 minutes

(6) Can I withdraw from the study?

Being in this study is completely voluntary - you are not under any obligation to consent and - if you do consent - you can withdraw at any time without affecting your relationship with The University of Sydney or XXXXX College.

INTERVIEWS: You may stop the interview at any time if you do not wish to continue, the audio recording will be erased and the information provided will not be included in the study.

SURVEYS: Being in this study is completely voluntary and you are not under any obligation to consent to complete the questionnaire/survey. You may skip questions or end the survey at any time. Submitting a completed questionnaire/survey is an indication of your consent to participate in the study. You can withdraw any time prior to submitting your completed questionnaire/survey. Once you have submitted your questionnaire/survey anonymously, your responses cannot be withdrawn.

(7) Will anyone else know the results?

A report of the study may be submitted for publication, but since survey responses are gathered anonymously and interview participant’s confidentiality is assured, individual participants will not be identifiable in such a report.

(8) Will the study benefit me?

We cannot and do not guarantee or promise that you will receive any benefit from the study.

(9) Can I tell other people about the study?

Yes, if you would like.

For Interview respondents: What if I require further information about the study or my involvement in it?

When you have read this information, Deborah Tully will discuss it with you further and answer any questions you may have. If you would like to know more at any stage, please feel free to contact the supervisor of this study, Prof. Anthony Welch; Anthony.welch@sydney.edu.au or Deborah Tully: dtul4703@uni.sydney.edu.au

(10) What if I have a complaint or any concerns?

You may also contact the Institutional Review Board at XXXX College: XXXXX, PhD. XXXX Hall XXX (XXX) XXX-XXXX  XXXXXX@XXXXXXX.edu

This information sheet is for you to keep
APPENDIX E
Interview Consent Form

Chief Investigator/Supervisor Name: Deborah Tully/Prof. Anthony Welch
Faculty of Education and Social Work
Room 405
Building A36
The University of Sydney
NSW 2006 Australia
Telephone: +61293516358
Email: dtul4703@uni.sydney.edu.au
Web: http://www.sydney.edu.au

I, .................................................................[PRINT NAME], give consent to my participation in the research project

TITLE: The path to persistence for women of color in STEM: a contextualized multiple case-study of women’s-only colleges, historically Black colleges and universities, and coeducational liberal arts colleges in the United States

In giving my consent I acknowledge that:

1. The procedures required for the project and the time involved have been explained to me, and any questions I have about the project have been answered to my satisfaction.

2. I have read the Participant Information Statement and have been given the opportunity to discuss the information and my involvement in the project with the researcher/s.

3. I understand that being in this study is completely voluntary – I am not under any obligation to consent.

4. I understand that my involvement is strictly confidential. I understand that any research data gathered from the results of the study may be published however no information about me will be used in any way that is identifiable.

5. I understand that I can withdraw from the study at any time, without affecting my relationship with the researcher(s) or the University of Sydney or XXXXXX College now or in the future.

6. I understand that I can stop the interview at any time if I do not wish to continue, the audio recording will be erased and the information provided will not be included in the study.
7. I consent to:

- Audio-recording  YES ☐ NO ☐
- Receiving Feedback YES ☐ NO ☐

If you answered YES to the “Receiving Feedback” question, please provide your details i.e. mailing address, email address.

Feedback Option

Address: ________________________________
______________________________

Email: ________________________________

...................................................
Participant Signature
...................................................

Please PRINT name

...................................................
Date