She Resides at the Intersections: How Race, Gender, and SES Shape Changes in Black Girls' Achievement and Affect in Math and Science Across High School

by

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Dedication

I dedicate this dissertation to my parents, Julie Suzanne Strahm Halawah and Walid Darwish Abu-il Halawah. Mom, thank you for being a role model for me – your demonstrations of working past personal struggles to provide for your family is honorable. I thank you for all of the sacrifices you made to ensure I had a healthy, safe, and enjoyable childhood. Dad, your life has been so much different than mine; filled with experiences that I cannot relate to. By way of the series of decisions that you have made, and the risks that you have taken, I will never have to. I am filled with gratitude for all that you both have given me, سُكْرَن (shukran).

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Abstract

Diversity in the workplace contributes to creativity, better problem solving, and increased innovation – all things that are necessary in professions in science, technology, engineering, and math (STEM) fields. The underrepresentation of Black women in STEM fields continues to be a persistent problem, and has implications for not only development in these fields, but also equity. Past research has identified that Black girls have a particularly positive relationship with science in middle and high school (Hanson, 2004). They tend to have more interest and positive attitudes in this subject relative to their White counterparts, and in college demonstrate a weaker implicit link between STEM fields and men (O'Brien, Garcia, et al., 2015). Reasons for this relationship may be rooted in racial and gender socialization, especially given that Black girls are often taught to be strong and independent (Jones Thomas, Daniel Hacker, & Hoxha, 2011; Kane, 2000) - traits that are typically associated with STEM fields (Cheryan et al., 2016; Nosek et al., 2009). Further, messages that Black girls receive about preparation for racial bias, may uniquely prepare them for experiences in fields that harbor bias against women.

Previous work has found that women from lower socioeconomic status (SES) backgrounds tend to select college majors that lead directly to a secure job post-graduation, such as those in STEM fields; whereas women from higher SES backgrounds demonstrate more flexibility in their choices

(Davies & Guppy, 1997; Ma, 2009a; Mullen, 2014). Thus, socialization within different SES groups may have implications for attitudes about education and career choice. In addition, the broad body of research on women and girls in STEM tends to lump all STEM fields into a single category, despite differences in perceptions of, level of interest in, and actual participation in these fields. High school is an especially important time to examine this topic given that this is a time of identity exploration and development (Phinney & Alipuria, 1990). Further pre-college decisions (e.g., course-taking) and attitudes have dramatic implications for future entry and persistence in STEM fields (Cheryan et al., 2016; Maple & Stage, 2008; Wang & Degol, 2017).

To extend current research on Black girls and STEM, the present study used data from the Youth Identity Project (YIP) to investigate whether changes occur for Black girls' math and science achievement and affect across high school, and examine how these changes might vary according to racial identity, gender identity, preparation for bias, and socioeconomic status.

Results revealed that there are changes in math and science that affect and achievement across high school, and that these changes do indeed vary among Black girls depending on their SES, racial centrality, gender centrality, and level of preparation for bias. This study extends knowledge of how identity and social group membership contributes to academic outcomes in science and math during high school. Findings provide information regarding how affect and achievement in science and math change across high school, and if they differ for among girls based on socialization, SES, and social identities. Understanding how changes in these outcomes differ by social identities and class may help to identify key population groups and points in development at which interventions can be targeted.

Chapter I

Introduction

Statement of the Problem

Science, technology, engineering, and math (STEM) fields are important to the U.S. global economy because the innovations and technologies that result from these fields provide security, prosperity, and economic stability for the U.S. (Babco, 2004). The lack of gender and ethnic diversity in these fields, however, is a persistent challenge that has implications for the quality of scientific knowledge and progress across multiple disciplines. A range of perspectives and experiences foster increased productivity, more efficient problem solving, and creativity in the workplace (Corbett & Hill, 2015) - all skills that are critical to tackling present day environmental, health, and infrastructural challenges. Further, the implications of the absence of women and people of color from STEM fields are evident in several domains. For example, in the past there have been instances wherein products that were intended to be useful for everyone, were only useful for select individuals. Early voice recognition software was unable to understand female voices, so women essentially were not being heard by this technology. Today these technologies have vastly improved, but some women still report issues with voice recognition systems integrated into newer vehicles (Palmiter Bajorek, 2019), thus highlighting the need for women to be involved in the process of creating this product. Apple Watch included an app that acts like a heart monitor, however soon after its release it was revealed that the app did not work for people with darker skin tones or tattoos (Taylor, 2015). Unfortunately, no one on the team who developed this app thought to consider how skin tone might affect performance. Lastly, there have been cases of automatic hand soap dispensers not working for those with darker skin tones (Fussell, 2017), thus posing health risks. These examples serve to highlight the need to diversify STEM fields. Adding diversity to STEM results in increased creativity and innovation fueled by different perspectives about issues and how to solve them, and produces products that are reflective of the needs and interests of the people who use them.

Evidence is suggestive of a unique gender system within the Black family and community that support Black women's involvement in traditionally male dominated domains, such as science (Hanson, 2009). Research suggests that within some Black families females are taught to place less emphasis on only traditional notions of femininity (e.g., nurturance and passivity), and more on the combination of feminine roles with being both strong and self-sufficient (Jones et al., 2011). This lack of rigidity allows Black females greater gender role flexibility (Kane, 2000), and may be advantageous in STEM settings, which are typically associated with males and masculine traits (Ramsey, Betz, & Sekaquaptewa, 2013). In their qualitative study Pearson and Bieschke (2001) found Black female STEM majors reported that they did not consider themselves bound to any one type of career due to their gender, and attributed this to the gender roles they were taught by their families. Family socialization and support systems may foster the development of resilience to common stereotypes about women's academic abilities in STEM. This could explain why more Black girls report intent to select a STEM major in college relative to their White counterparts (Hanson, 2004) and in college samples Black women have demonstrated weaker gender-STEM stereotype associations relative to Whites (O'Brien et al., 2015).

Adequate training and exposure to STEM prior to higher education is critical for persistence in a STEM degree program (Wang, 2013), and previous work indicates that high school is not too late to initiate positive affect (e.g., perceptions of competence, level of interest) and achievement toward these domains (Blanchard Kyte & Riegle-Crumb, 2017). That said, girls' achievement and affect in STEM subjects tends to decline over time, particularly during the transition into high school and higher education (American Association of University Women [AAUW], 1990, 1998; Eccles,1993; Watt, 2008). However, there is a degree of racial and ethnic variation among girls' attitudes toward and perceptions of science and math (Hanson, 2007, 2009; O'Brien, Blodorn, Adams, Garcia, & Hammer, 2015; Riegle-Crumb, Moore, & Ramos-Wada, 2011), suggesting that these trajectories might not apply to all girls. To further compound this, the large body of work documenting links between socioeconomic status (SES) and achievement gaps in STEM seldom considers how SES, race, and gender intersect to contribute to educational outcomes in STEM subjects specifically for Black girls (Bécares & Priest, 2015; Butler-Barnes et al., 2018; Chavous & Cogburn, 2007; Cheryan, Ziegler, Montoya, & Jiang, 2016). Not only does this limit knowledge of unique vulnerabilities, but also assets that might occur at the intersection of some social identities.

Similar to assuming that all girls have the same perceptions of and experiences in STEM subjects, research on this topic tends to treat STEM as a single broad category (Cheryan et al., 2016; Mann & DiPrete, 2013; Su & Rounds, 2015). However, there are key differences between fields within STEM that must be addressed. For example, adolescents tend to view math and science as largely distinct, despite the level of overlap between these subjects (Blanchard Kyte & Riegle-Crumb, 2017). Further, girls often report more positive attitudes in science, relative to math, and when asked which they could see themselves pursuing a career in, are more likely to indicate science (Blanchard Kyte & Riegle-Crumb, 2017; Cheryan, 2012; Siani & Dacin, 2018). A singular focus on STEM as a broad category limits the understanding of critical differences between these subjects, thus obscuring opportunities to support girls' participation in fields in which they historically have demonstrated the least amount of interest. Given that youth view these domains as distinct, and girls display more interest in science, comparisons between the subjects is critical.

Current Limitations in the Research

The volume of research on girls and women in STEM is expansive (Kanny, Sax, & Riggers-Piehl, 2014), yet important gaps remain. First, this body of research tends to collapse all females into a single category, despite known racial variation in representation, experiences, and attitudes toward STEM (Hanson, 2004a; O'Brien, Blodorn, et al., 2015; Riegle-Crumb & King, 2010; Riegle-Crumb et al., 2011). Consider that White women make up 18% of the U.S. STEM labor force; whereas Black women comprise just two percent of U.S. STEM employees (NSF, 2017). This presents an important area for research inquiry, as the path to diversifying these fields requires development of empirical work that reflects the experiences of girls and women from varied racial and ethnic backgrounds.

Second, SES is consistently correlated with achievement and persistence in STEM (Xie, Fang, & Shauman, 2015), as high SES families have resources that other families are often unable to afford, such as tutoring, additional education opportunities, and social capital (Hrabowski, Maton, Greene, & Greif, 2002; Maton, Hrabowski, & Schmitt, 2000), although a high SES does not automatically guarantee STEM achievement. Underrepresented minority (URM) youth from low-SES backgrounds have reported high aspirations for math and science (Riegle-Crumb et al., 2011), and researchers suggest that family-related factors such as race and gender socialization, may play a role in shaping STEM attitudes (Hanson, 2004, 2007, 2009; O'Brien et al., 2015). For example, Black parents and their children report less gender stereotypic beliefs about math abilities and performance (Evans, Copping, Rowley, & Kurtz-Costes, 2011; Rowley & Kurtz-Costes, 2007). Additionally, Pearson and Bieschke (2001) found that Black female STEM majors reported that they did not consider themselves bound to any one type of career due to their gender, and reported attributing this to the gender roles they were taught by their families. Relative to achievement, the role of SES in relation to science and math affect is less clear. Perry and colleagues (2012) provided evidence that low SES had a smaller influence on girls' science self-concept relative to boys', and Lubienski and colleagues (2011) found that gender differences in math performance were larger among students from higher SES families. Thus, the role of SES in the context of science and math affect and achievement for Black girls needs to be further explored.

Third, of the research on URM women and girls in STEM, most focuses on undergraduates, yet STEM persistence has earlier roots. Attitudes about math and science begin to form as early as elementary school (Cvencek, Meltzoff, & Greenwald, 2011; Master, Cheryan, Moscatelli, & Meltzoff, 2017; Wang & Degol, 2013), and are linked with persistence in STEM (Tai, Liu, Maltese, & Fan, 2006), therefore documentation of Black girls' math and science affect prior to higher education is critical to reducing their leakage from further points in the STEM pipeline. Moreover, data suggests that girls' STEM interest tends to decline during high school (Sadler, Sonnert, Hazari, & Tai, 2012), but the pattern may not be identical for Black girls, who report more positive attitudes toward science relative to their White counterparts during middle and high school (Hanson, 2004). Attending to within group differences among girls reveals how math and science attitudes and interest changes over time for specific groups of girls, and, in particular, the unique role that race and gender plays in Black girls' math and science trajectories during high school.

Lastly, there has been little emphasis on comparisons between subfields of STEM. The acronym STEM includes many academic fields, and it should be noted that women's participation in the subfields classified as STEM varies widely (Blanchard Kyte & Riegle-Crumb, 2017; Cheryan et al., 2016; Ma, 2011; Mann & DiPrete, 2013; Shishkova et al., 2017; Su & Rounds, 2015). Few studies make comparisons between STEM subfields (Blanchard Kyte & Riegle-Crumb, 2017; Cheryan et al., 2016; Kanny et al., 2014; Ma, 2011; Rincón & George-Jackson, 2016; Sax, Kanny, Riggers-Piehl, Whang, & Paulson, 2015), however research that disaggregates these fields is critical to increased understanding of the factors that deter and support women's participation in the fields wherein they are grossly underrepresented—thus, yielding information that contributes to more efficacious interventions.

Purpose

Responding to the gaps in the literature regarding (a) within group variation among girls' math and science affect and achievement, (b) STEM subfields aggregation, and (c) the role of race, gender, and SES for girls' in the context of math and science prior to college, project aims included: (1) investigate whether changes occur for Black girls' math and science achievement and affect across high school, and (2) examine how these changes might vary according to racial identity, gender identity, racial socialization, and socioeconomic status. Understanding how changes in these outcomes are potentially differentially patterned by social identities and class may help to identify key population groups and points during high school at which interventions can be targeted.

Significance and Contributions

This study extends the literature on females in STEM in three primary ways. First, previous research has examined how variables such as math motivation, math identity, and math self-concept change over time (e.g., Petersen & Hyde, 2017), however most work has attended to differences between boys and girls rather than within group variation among girls. The present study contributes to the literature through a specific focus on identifying within group variation among Black girls in high school. Second, work on this topic is typically limited to testing one domain at a time or collapsing all fields instead of providing comparisons between STEM fields. Deliberate comparisons of math and science will yield important findings regarding how performance and affect in these domains relate to identities that are relevant during this period in adolescence. Third, no studies (to date) have examined how the associations among STEM affective variables (e.g., interest, expectations) and achievement (e.g., grades) might vary by racial and gender identities, racial socialization, and SES. The inclusion of SES in unique and a critical piece of learning more about how race and gender identities interact with social class to inform outcomes in science and math among Black girls.

Summary and Organization

As a broad topic of inquiry, the underrepresentation of women in STEM fields has received considerable scholarly attention. Despite this, diversifying these fields remains a persistent problem. Moreover, there are still many paths of inquiry within this broad topic that remain underexplored. Namely disaggregating fields within STEM and the use of an intersectional approach to highlight the experiences of Black girls. To extend current research, this study examines changes in math and science achievement and affect and probes how these changes operate/vary in the context of differing social identities and social class. Findings can contribute to intervention work that uses a more targeted approach to garnering and sustaining Black girls' participation in STEM during the pre-college years, thus fostering increased opportunity for diversity among those in the STEM workforce.

Chapter I described the social issue and provided an overview of the research topic. Chapter II includes a summary of the relevant literature, including the theories used to frame they study. Chapter III describes the methods used, demographic information about the sample, and the analytic plan for the present study. Chapter IV reports study findings pertaining to the research questions. Lastly, interpretation of findings, strengths, limitations, and future directions are included in Chapter V.

Chapter II

Literature Review

Race and gender socialization for Black girls may uniquely prepare them for participation in domains wherein they have been historically underrepresented and discriminated against. Further, some STEM fields have more female representation relative to others, and it is unclear how the intersection of race, gender, and SES contribute to Black girls' affect and achievement in these domains, particularly prior to higher education.

Theoretical Framework

Intersectionality was coined by Kimberle Crenshaw, a legal scholar and critical race theorist, who noted that Black women were often neglected in the law and anti-discriminatory practices. Intersectionality is conceptualized as a theoretical approach to understanding the meaning of and implications of occupying multiple social categories (e.g., race, class). With roots in Black feminism and critical race theory, intersectionality has been applied in many academic fields (Else-Quest & Hyde, 2016) and offers a lens through which to simultaneously interpret the social categories and power structures that inform individual perceptions, opportunities, and experiences. The social identities that individual Black women and girls' have are often overshadowed by either race-based (favoring Black males) or gender based (favoring White females) research and political agendas (Evans-Waters & Esposito, 2010). Crenshaw (1989) suggested that

> "… this focus on otherwise-privileged group members creates a distorted analysis of racism and sexism because the operative conceptions of race and

sex become grounded in experiences that actually represent only a subset of a much more complex phenomenon. (p.57)"

Counter to a single-axis view of society, she noted that the simultaneous analysis of race, gender, and other identities is critical to understanding the experiences of women of color. In addition to an emphasis on concurrent analysis of intersecting identities, intersectionality considers how social identities position individuals within hierarchical power structures. Social identities such as race, gender, and social class hold historical and political significance, and as such contribute to various forms of inequality. The use of an intersectional approach draws attention to the interplay between a person and their social location, and emphasizes that identities such as race and gender are indeed social categories and not simply personal characteristics.
Black girls and women's needs and experiences are still neglected today. Educational literature on Black adolescents is dominated by a focus on Black males, which obscures the experiences and challenges that Black girls also face.

High school as a developmentally important time

During high school students make decisions and form attitudes that will impact their career trajectory in important ways. For example, which classes they take, what activities they become involved in, their plans and goals all shape educational and career aspirations. A longitudinal mixed methods study found that women who were majoring in a STEM undergraduate degree program reported that their growing sense of identity as scientists and eventual educational choices had been developed by earlier life experiences, including role models and learning experiences (Buschor, Berweger, Frei, & Kappler, 2014). Preparation for STEM in college is critical during high school if students want to enter into a STEM field (Maple & Stage, 2008). Adequate training and exposure to STEM prior to higher education is critical for STEM degree persistence (Cheryan et al., 2016; Wang, 2013), as previous work finds higher attrition rates among individuals in STEM majors who took fewer science and math courses in high school (Chen, 2013; Gonzalez, Heather; Kuenzi, 2012)

Beyond the need for training and exposure to STEM in high school, several theories suggest that identity exploration is an important developmental task during adolescence (Pahl & Way, 2006; Phinney, 1990; Phinney & Alipuria, 1990; Theisen & Erikson, 2007). Thus, this period of adolescence offers a view of how identity development shapes eventual educational and career outcomes, and more specifically outcomes in science and math.

Erikson proposed that identity formation is the key developmental task during adolescence (Erikson 1968; 1972), and youth have to define their identity in the midst of both internal and external demands, such as personal and social expectations. He acknowledged that culture plays a role in this process, but only so much as a contextual backdrop for this development. Furthermore, his theory suggested that the developmental task of *identity versus identity confusion* is stable and universal. Tajfel's, (1981) social identity theory took Erikson’s theory further by addressing the importance of social group membership, and suggests that experiences associated with minority social identities can be most influential to one’s identity. According to Tajfel aspects of identity are derived from knowledge of membership in a particular group, as well as the emotional value and importance attributed to being part of that group. Thus, a major challenge that URM youth face is establishing a positive sense of identity when they belong to a social group that has been consistently marginalized in society. When considered together, these theories provide a more complete explanation of why adolescence is such an important time to study identity. Erikson's work suggests that it is the level of importance that the youth puts on their identity that is critical to identity formation, and Tajfel's work suggests that it is the connections with self-identified social groups that propels identity formation.

The concept of race is particularly salient for Black adolescents (Crocker, Luhtanen, Blaine, & Broadnax, 1994; Phinney, 1990; Phinney & Alipuria, 1990). Along with identity development, an individual has to negotiate how their identities fit within their broader context. Negotiating this may mean realizing their group's value relative to that of other groups. People of color are generally devalued in the U.S. (French, Seidman, Allen, & Aber, 2006) and women are generally considered less capable relative to men in the context of STEM (Cheryan et al., 2016; Cvencek et al., 2011; Nosek et al., 2009). Yet, some research indicates that Blacks have higher self-esteem than Whites (French et al., 2006) and Black girls report more interest in science relative to White girls (Hanson, 2004, 2009; Riegle-Crumb et al., 2011). Part of the identity negotiation and development that occurs during adolescence may be important for Black girls in the context of STEM as they consider how they fit into these fields. Further, it may be especially important for them to have a positive racial and gender identity to explore what it means to be a member of their group, as personal views may lessen biased expectations and judgments from others. In other words, how the individual makes sense of their social group membership and the degree to which it is personally important to their sense of self has implications for how they relate to others.

Historical Context — Black Women and Work

Gender roles and attitudes about gender within families vary by racial and ethnic group (Hanson, 2009; Kane, 2000; Thomas, Hacker, & Hoxha, 2011). Past research indicates that some Black families have more egalitarian gender roles, and other research has found that Black male and female college students report similar associations between men and math and science (O'Brien 2015). However, to understand the present and put the future in context, it is critical to understand the past.

Black women in the United States have always had to work, and, prior to the abolition of slavery, there was no strict division of labor by sex (Jones, 1982). The division of labor was not based in White traditional values, but more or less the decisions of the slave owner. Black women were not relegated to only household tasks, and instead both toiled in the fields and took on domestic duties. Slave owners viewed Black men and women as essentially economic equals – after all, as they saw it, women could do the physical work of men, plus reproduce and care for children. For this, Black females bore the brunt of a dual status life as an able-bodied slave and household worker. She worked in their fields alongside her male counterparts, in the "Big House" as a domestic worker, and within slave communities, often taking on domestic tasks and care-taking roles. Following emancipation, social expectations from Whites, dictated that Black women should work. The combination of race, class, and gender encouraged different expectations for Black and White women in relation to work (Brooks Higginbotham, 1992). Even Black married women were expected to work, as White society deemed it "unnatural" and "evil" for her to be financially supported by her husband (Jones, 1982). This laid the foundation for the experiences and expectations that Black women today experience in relation to work in the U.S.

A rich family lineage of resiliency and drive have helped to shape Black women's attitudes and outcomes in STEM fields. I posit that these sentiments have been passed down over generations and contribute to gender roles and attitudes about gender within many Black families that still hold today. Expectations for Black men and women to do the same work influenced and defined how Black women are perceived and how they perceive themselves in the context of society, work, and more specifically, STEM fields. Intergenerational transmission of these sentiments are likely contributors, and may explain why during high school more Black girls report intent to select a science major in college relative to their White counterparts (Hanson, 2004; Smyth & Mcardle, 2016), and why in college samples, Black women show weaker gender-STEM stereotype associations relative to White women (O'Brien et al., 2015). Messages about race and gender may uniquely prepare Black girls to negotiate their identities in challenging and potentially biased environments (i.e., STEM fields).

Race and gender socialization

Research pertaining to family influences on girls in STEM has investigated mechanisms that exert influence, such as parent educational involvement, but often neglects to address the intangible resources that parents may provide to their daughters, such as their socialization. Skills rooted in race and gender socialization may buffer against some of the barriers that are present for Black women in STEM fields.

A unique gender system within some Black families appears to support women's involvement in traditionally male dominated domains, such as science (Hanson, 2009).

For instance, many Black adults have reported that traits typically associated with males, such as independence, are not considered to be strictly masculine characteristics (Wade, 1993). One feature of family influence that seems to be particularly positive for Black women in STEM is the socialization of gender-role flexibility. For example, Black parents and children report less gender stereotypic beliefs about math abilities and performance (Evans et al., 2011). This finding is important because research has demonstrated that endorsing gendered academic stereotypes has consequences for girls' academic performance and self-perceptions (Plante, de la Sablonnière, Aronson, & Théorêt, 2013; Schmader, Johns, & Barquissau, 2004; Shapiro & Williams, 2012). For example, Pearson and Bieschke (2001) found that Black female STEM majors reported that they did not consider themselves bound to any one type of career due to their gender and attributed this to the gender roles they were taught by their families. Other research suggests that within some Black families, females are taught to place less emphasis on just traditional notions of femininity (e.g., nurturance and passivity), and more on the combination of feminine roles and being both strong and self-sufficient (Jones et al., 2011). This lack of rigidity allows Black females more gender role flexibility (Kane, 2000), and may be advantageous in STEM settings, which are typically associated with males and masculine traits (Ramsey et al., 2013). Direct and indirect messages about race and gender may uniquely prepare Black girls to negotiate their identities in challenging and potentially biased environments (i.e., STEM fields).

In addition to gender socialization, racial socialization may serve as an important factor for Black girls' educational development in science and math. Racial socialization is an important dynamic within Black families through which they provide messages about race to children (Hughes et al., 2006; McHale et al., 2006). A critical component of this socialization is “preparation for bias”, which aims to increase youth’s awareness of biases and barriers and prepare them to cope with these stressors (Hughes et al., 2006). Preparation for bias among Black families may be one of the child-rearing strategies that has been passed down from generation to generation resulting from the intergenerational transmission of the shared experience of oppression (Ward, 1991).

It is generally assumed that racial socialization leads to positive outcomes for Black youth, although there are mixed findings with respect to preparation for bias. For example, some work has linked preparation for bias with academic motivation among Black youth (Hughes et al., 2006; Neblett, Philip, Cogburn, Sellers, 2006); whereas other research finds associations with lower school performance (Smith, Atkins, & Connell, 2003) and less school engagement (Smalls, 2009). Additionally, there are discrepancies between what messages parents report providing and adolescents report receiving. For example, Hughes et al. (2006) found that just under half of their Black parent-child dyads reported similar rates of cultural socialization and preparation for bias. Similarly, Hughes and colleagues (2009) found inconsistencies in Black youth’s and mothers’ reports of racial socialization messages, such that many youth did not recall messages that mothers outlined in great detail. In light of mixed findings regarding outcomes associated with preparation for bias, it is critical to acknowledge that ethnic promotive factors may operate differently within a racial group, such that, Black youth may be more attuned to some messages more than others.

Since stereotypes about gender and gender itself seem to function differently across racial and ethnic groups, consideration of the intersection of race and gender is critical to understanding the processes contributing to Black girls' trajectories in STEM. Socialization may promote a resilience to common stereotypes about women's academic abilities in STEM. However, how youth interpret and respond to messages about race, gender, and bias in relation to their identities certainly influences how they develop within the educational system.

SES and STEM

Class compounds the effects of race and gender for Black girls from low SES families as these girls typically attend schools with fewer resources, and thus are not as prepared for a STEM major relative to their higher SES peers (Hrabowski, Maton, Greene, & Greif, 2002; Maton, & Schmitt, 2000). A robust body of work provides evidence that larger contextual barriers, such as stratification in the American educational system, limit STEM-related educational opportunities for low-income Black girls, which has a profound influence on students' educational interests and decisions prior to higher education. Children of color are more likely to be in a family living at or below the poverty line and are three times more likely to attend urban, under resourced schools than their White counterparts (Orfield & Lee, 2005). As a result, these students have limited access to technologically savvy teachers, advanced science and math courses, and up to date textbooks (Hamrick & Stage, 2004; Simard, 2009). Lack of exposure to STEM makes it difficult to be successful in math and science, and certainly limits the opportunity to envision a future career in one of these domains.

Socioeconomic status is strongly associated with student achievement and interest in STEM throughout the pipeline (Xie et al., 2015), although several studies have found that, when controlling for academic achievement, STEM interest and persistence in college does not vary between students from different SES backgrounds (Ma, 2011; Mau, 2003; Oguzie, Onuoha, & Onuchukwu, 2005). Further there may be sex differences in how SES impacts STEM affect. Using a racially diverse sample of young adolescents, Perry and colleagues (2012) found that the low-SES girls in their sample had higher science self-confidence relative to their low-SES male counterparts; whereas the reverse pattern occurred for those from higher SES families. Thus, the role of SES in STEM interest and achievement may not be as straightforward as previously thought.

SES may be a predictor of academic achievement and persistence; however, it provides no guarantees of academic achievement. Other family-centered variables, such as socialization may be equally, or more, important. Black families and communities have long valued higher education as the gateway to a better future for the next generation (Bowman, 1985; Griffin, del Pilar, McIntosh, & Griffin, 2012), and many families begin nurturing Black females at an early age to achieve more than they did and motivate them to do their best and be their best in their academic achievements (Chavous & Cogburn, 2007; Smith & Fleming, 2006). Family SES transmits inequalities from generation to generation, however it may also be a force toward upward mobility for Black girls, particularly if economic utility in relation to education is emphasized. Some research has found a link between college major and student SES, suggesting that lower SES students are drawn to careers that are likely to yield financial stability and higher pay. STEM employees tend to have greater job security (Langdon, McKittrick, Beede, Khan, & Doms, 2011) and higher pay (Beede, Julian, & Langdon, 2011) relative to those who work in non-STEM fields. Using the National Education Longitudinal Study (NELS) Ma (2009) found female college students from a low SES background were more likely to choose a "lucrative" college major, such as technical, life/health science, and business, over humanities, social science, and education majors, which tend to yield lower lifetime earnings. Using a mostly White sample, Mullen (2014) found similar results, wherein students selected majors which they thought would lead to future financial satiability and a secure job.

Beyond findings at the aggregate, Ma (2009) found important interactions between SES and sex. Female students from higher SES backgrounds were more likely to select a humanities, education, or social science major; whereas those from lower SES backgrounds were more likely to select a major that would lead to a lucrative career, such as business, science, or a technical field. Other studies have corroborated these finds as well. Drawing from data from the National Center for Education Statistics (NCES) Leppel, Williams, and Waldauer (2001) found sex differences in the effects of socioeconomic status on occupational preference and choices, such that the effects of SES were stronger for women relative to men. Further, Mullen (2014) found higher SES students demonstrated sex differences in the majors selected; whereas for lower SES students there were no sex differences in majors – both men and women from low SES background selected majors based on practicality. Meaning, women from low SES backgrounds demonstrated behavior with major selection that was more similar to males from low and high SES backgrounds than it was to females from high SES backgrounds.

There seems to be an important relationship between SES, sex, and educational goals, such that the promise of high pay and job stability trumps gender role expectations for women from lower SES backgrounds. Coming from a low SES family may limit educational opportunities, but it may also override expectations for gendered occupational decisions. This can open up opportunities for women's increased involvement in STEM fields, and these ideas likely begin to form prior to higher education.

Changes in STEM affect and achievement over time

Across development youth typically experience declines in math affective variables, such as interest, enjoyment of math, and value of math (Fredricks & Eccles, 2002; Köller, Baumert, & Schnabel, 2001; Watt, 2006). Using growth curve modeling, Frenzel and colleagues (2010) mapped the trajectories of intrinsic math interest of adolescents across middle and high school and found that interest tends to decline. A retrospective study, by Sadler and colleagues (2012), of nationally representative first-year college students who attended either a four-year or two-year institution found that girls' interest in a STEM career declined across high school. In contrast, with science affective variables, there seems be to a greater deal of variability. Drawing from a predominately White sample of youth from middle and working class families, Wang and colleagues' (2017) findings revealed a great deal of heterogeneity among students' trajectories in science affective variables as they moved from 7th grade through the end of high school. Seven different trajectory groups were found indicating that not all youth demonstrate declines in science affect across adolescence.

Similar to math affect, math achievement often declines as youth transition to higher levels of education (American Association of University Women [AAUW], 1990, 1998; Eccles, 1993; Watt, 2008). For example, Shapka (2009) found that math achievement sharply decreased across high school. In contrast, similar to science affect, there is greater inconsistency in the findings for science achievement and changes over time. Some data suggests that girls achievement in science subjects slightly increases with time (Muller et al, 2007; Larose et al., 2006); and other studies that have employed a person-centered approach to tease out different growth trajectories have found some girls' science achievement remains stable across high school and others' either increase or decrease (Larose et al., 2006).

Previous research has examined how variables such as math motivation, math identity, and math self-concept change over time (e.g., Peterson & Hyde, 2015), however, most scholarly work has attended to differences between boys and girls rather than within group variation among girls. Many scholars have noted the merits of examining variation by racial group (e.g., Wang et al., 2017; Riegle-Crumb 2011), particularly given that previous research has found evidence that, on average, students' affect and achievement in math and science tend to vary more by ethnicity than by sex (Muller, Stage, & Kinzie, 2007).

There is a dearth of research examining changes in math and science achievement and affect specifically using Black female samples. Of the available research, it has been noted that Black girls' achievement trajectories in math and science are similar to their White counterparts, however Black girls' achievement tends to be lower (Catsambis, 1995; Hanson, 2004; Muller, Stage, & Kinzie, 2007). But there are differences among girls with respect to math and science affective variables, as Black girls tend to have more positive affect (Catsambis, 1995; Hanson, 2004b; Riegle-Crumb et al., 2011). Though, previous work has found that Black girls have a particularly positive relationship with science (Hanson, 2004a, 2006), significantly less is known about their experiences and outcomes in math (Gholson, 2016; Gholson & Martin, 2014).

Through social and educational experiences, Black girls learn that math and science are male domains, which may conflict with their own identities, self-perceptions, and expectations. Girls are exposed to messages about who is good at and belongs in math and science across their development from various sources. Encounters with sexist behavior from others in the context of math and science reinforce these stereotypes, and for Black girls the lines between racism and sexism can be blurred. This likely bolsters observed declines in affect and achievement over time, but there may be more variation among Black girls than previously acknowledged.

Math versus Science

Few studies make comparisons between STEM subfields (Cheryan et al., 2016), despite well documented differences in women's participation between the subfields. Fields such as biology often have high female participation, particularly at the undergraduate level; whereas the participation of women in areas such as physics is scarce at all levels (Blanchard Kyte & Riegle-Crumb, 2017; Liben & Coyle, 2014). For example, in 2018, roughly 60% of degrees in Biology were earned by women, and about 15% of the bachelor’s degrees earned in Physics were earned by women (APS; IPEDS, 2018). Despite that there is indeed a level of overlap between science and math, adolescents, tend to view these subjects as largely distinct (Blanchard Kyte & Riegle-Crumb, 2017). To explain why this occurs, I draw from literature on gender theories, career development, and stereotypes.

According to social cognitive career theory (SCCT), girls are socialized into careers that have direct applicability to helping others (Diekman, Brown, Johnston, & Clark, 2010), and this tends to be reflective of the current gender composition in STEM fields in the United States. In their meta-analysis, Su and colleagues (2009) found that women scored higher than men on a scale indicating more interest in helping people. Using a sample of first-year high school students from a large, urban, low-income, and predominantly minority-serving school district, Blanchard-Kyte and Riegle-Crumb (2017) found girls who perceived science as more socially relevant also indicated a stronger desire to major in a STEM field in college. Examples of women in helping-oriented careers in science are more abundant – for example, doctors, nurses, psychologists (Cheryan et al., 2016). Further, youth have less exposure to information about how career opportunities in fields that are associated with males, such as engineering and computer science, contribute to society (Godwin & Potvin, 2017; Meyer, 2017). Youth are attuned to this, and perhaps this contributes to how they view certain STEM fields.

Stereotypes about math and science environments and who is employed in them differ. Youths’ awareness of these stereotypes emerge at a young age, as girls begin to endorse math as a male domain beginning in the second grade (Ambady, Shih, Kim, & Pittinsky, 2001; Cvencek et al., 2011). Though STEM fields overall are associated with males and masculine traits (Cheryan et al., 2016; Nosek et al., 2009), biology and chemistry are perceived to have a significantly lower proportion of men relative to other fields within STEM (Matskewich & Cheryan, 2016), which is likely due, in part, to how gender is actually reflected in these fields. Further, social perceptions of who is adept in math are ability based, suggesting that math skills are innate (Deemer, Thoman, Chase, & Smith, 2014; Master et al., 2015); whereas in the context of science, there seems to be more flexibility. Despite that science and math are both associated with males and masculine traits (Cheryan et al., 2016; Nosek et al., 2009), fields that rely heavily on quantitative skills, such as computer science, engineering, and physics, are commonly perceived as requiring innate talent more so relative to fields such as biology and chemistry (Cheryan et al., 2016). Because social expectations for initial ability in science are more flexible, girls may feel that they can integrate this domain into their identity, which corroborates the educational literature on the benefits of a growth mindset.

Beyond the need to disentangle similarities and differences between STEM subfields, previous research has provided substantial evidence of the importance of considering the intersection of race and gender for Black girls in science (e.g., Hanson, 2004, 2006, 2007, 2009), but less has been established regarding how these identities might exert influence for Black girls in the context of math. It may be the case that negative stereotypes about math are considered less applicable to Black girls, which may explain why, in college samples, Black women show weaker gender-STEM stereotype associations relative to White women (O'Brien, Garcia, et al., 2015). The authors posit that racial and gender socialization play a role in these outcomes, but it is not clear how this translates to differences in participation between STEM subfields.

According to the NSF (2019), Black women's representation in psychology, the social sciences, and the biological sciences has dramatically increased over time; whereas, their participation in engineering, math, statistics, and computer science is decreasing. The reasons for this are unclear, though signals that an increased emphasis on disaggregating STEM fields in scholarly work on this topic is necessary as it will yield an improved understanding of the factors that deter and support Black girls' in fields wherein they are grossly underrepresented.

The importance of social identities

Racial identity. Sellers and colleagues (1998) identified multiple dimensions of racial identity, including racial centrality, racial salience, racial regard, and racial ideology. Of interest to this study was racial centrality - how central race is to an individual's self-concept, because the focus of this study was to examine how being a part of a particular group and identifying with that group impacts the individual. Racial centrality has been linked with several positive outcomes for Black individuals, such as a greater sense of well-being, academic achievement, and higher school self-efficacy (Butler-Barnes et al., 2018; Byrd & Chavous, 2011; Chavous, Rivas-Drake, Smalls, Griffin, & Cogburn, 2008; Rowley, Sellers, Chavous, & Smith, 1998; Sellers, Copeland-Linder, Martin, & Lewis, 2006). Though there has been little empirical work on racial identity in relation to academics for Black girls, findings suggest that high racial centrality is beneficial (Butler-Barnes et al., 2018; Chavous et al., 2008). For example, Chavous and colleagues (2008) found racial centrality moderated the effects of peer-based racial discrimination on girls' beliefs about the importance of school, such that among girls who experienced this discrimination and who had high racial centrality reported stronger beliefs about the importance of school. Despite this, there is little empirical work that examines racial centrality in relation to academic outcomes in science and math, specifically, among Black girls (Butler-Barnes et al., 2018). Research on this topic is needed as Black girls are often overshadowed by work examining Black boys in relation to academics.

Although most research suggests a positive link between having high racial centrality and academic achievement and well-being, there is some evidence that this may not always be the case. Strong racial identity has been found to buffer against factors such as discrimination (Butler-Barnes et al., 2018; Mossakowski, 2003), which Black women report is common in STEM domains (Alexander & Hermann, 2016; Gibson & Espino, 2016; Ireland et al., 2018; McGee & Bentley, 2017). This suggests that a person who views race as central to their identity may have a stronger connection to this group, which can serve to be protective during experiences of personal discrimination. On the other hand, strong racial identity may result in a heightened awareness of discrimination, and an individual might internalize negative experiences. Thus, it is unclear if having high racial centrality is protective or harmful for Black girls in the context of science and math during high school.

Gender identity. Of particular interest to this study was the concept of gender centrality, or the degree to which gender is central to one's sense of self (Settles, 2004). Gender centrality was selected because the focus of this study was to examine how being a part of a particular group and identifying with that group impacts the individual. Similar to racial centrality, gender centrality also plays a role in positive psychological outcomes (Saunders & Kashubeck-West, 2006; Settles, Jellison, & Pratt-Hyatt, 2009;

Settles, O'Connor, & Yap, 2016; Yakushko, 2007). Settles and colleagues (2016) found among undergraduate women majoring in a STEM field, gender centrality acted as a buffer between feelings of interference between science and woman identities and psychological well-being, such that those who did not view gender as central to their identity and reported woman-scientist identity interference, experienced lower well-being.

It is unclear whether gender centrality always leads to positive outcomes, as there is concern that these findings do not apply to all women given that there is racial and ethnic variation in conceptualizations of what it means to be a woman (Settles, 2006). Szymanski and Lewis (2016) found that gendered racial identity centrality did not play a buffering role in the relation between gendered racism and psychological distress among sample of college-aged Black women. Though scholars have studied gender identity in relation to educational outcomes for girls in STEM subjects (e.g., Jones & Myhill, 2004; Kessels, Heyder, Latsch, & Hannover, 2014), indicating that the female gender identity is perceived as incompatible with male stereotyped domains, there is a dearth of research on the role of gender centrality in relation to girls' educational development in these subjects. However, this fails to acknowledge individual differences, therefore discounting the role of other intersecting identities (e.g., gender, SES) that also shape the individual.

Identity centrality may support academic motivation and engagement through affective connections to academics, which encompass an individual's perceptions, feelings, beliefs, and attitudes about a given event or topic (Hyde, Fennema, Ryan, Frost, & Hopp, 1990). For example, links between racial affect and academic engagement have been found, suggesting that positive attitudes toward one's racial group and a strong group connection promotes positive academic outcomes (Murdock, 1999; O'Connor, 1999;). In the context of science and math, high affect is generally associated with more positive attitudes, higher achievement, less math anxiety, and higher motivation (Eddy & Brownell, 2016; Else-Quest, Hyde, & Linn, 2010; Hyde et al., 1990). Identity centrality may function similarly, such that through high identity centrality facilitates a higher sense of belonging, increased motivation, and higher self-efficacy in a given academic domain.

At the intersections. Most intervention work for girls and women disproportionately benefits White females and race-based intervention work tends to favor Black males (Ong, Wright, Espinosa, & Orfield, 2011) – thus leaving Black girls and women out of the equation. This is problematic because it does not acknowledge how race, gender, class, and other identities simultaneously inform individual perceptions, experiences, and outcomes in these domains. Further, single-axis programs inherently do not confront the realty that certain identities produce a degree of power and privilege for only some individuals.

Many interventions for women in STEM have heavily recruited women who are more represented in STEM, such as Whites and Asians (O'Brien et al., 2019). As a result, these may leave out components that are more useful or relevant to women from other racial groups, thus benefitting some more than others. For example**,** Falco and Summers (2017) created a career group intervention for high school girls that was composed of nine 50-min group counseling sessions over a period of 9-weeks aimed to improve career decision self-efficacy and self-efficacy in STEM fields. Each session had a theme, including: interests and values, occupational information, perceived barriers to success, growth-mindset, personal successes, attending to negative emotions, role models and future possible selves, positive affirmations, and lastly goal setting. The girls experienced increases in career decision and STEM self-efficacy from pre- to post-intervention and continued increases were apparent at a 3 month follow-up. While seemingly comprehensive, there was no indication that there was any discussion of race or ethnicity and bias or barriers that may be present in STEM. Girls were instructed to journal about their thoughts on this, but without any sort of follow-up, non-White girls may not be aware that their feelings may be shared by other girls of color, this may enhance a sense of isolation. Gendered academic stereotypes may be less relevant for Black girls as the prototypical target is a White woman, thus they may benefit less from intervention components that focus on just gender. Consider that Biernat and Sesko (2013) found in mixed-sex engineering work teams White women were evaluated more negatively relative to White men, but Black women were not.

Sometimes interventions that are meant to help minorities broadly, benefit men more, or fail to acknowledge women. For example, Jordt and colleages (2017) used a values affirmation intervention for students in an introductory to Biology course to counter stereotype threat and increase feelings of self-worth. Those in the treatment group were provided with a list of 14 items they might consider valuable in their lives (e.g., independence, athletic ability, social group membership), and were asked to select 2-3 values that were more important to them and write a brief response explaining why they selected those. Students in the control were provided the same list, but were asked to select 2-3 of the least important one to them and write a response about why the values would be important to someone else. The intervention was framed as a class writing exercise and was completed during the first week of the semester and after receiving feedback on their exam. Results indicated that the intervention reduced the Black-White achievement gap in the course using final grade scores, however an analyses investigating differences by gender revealed that URM males benefited more than their female counterparts. Another intervention program to increase URM representation in the sciences focused on mitigating the effects of stereotype threat on academic goals and future employment in a scientific domain (Woodcock & Bairaktarova, 2015). Students in the program were 1.74 times more likely to be engaged in, or training for, a scientific career than students from the matched no-program control group 4.5 years post-baccalaureate, although no analyses were performed to tease apart potential sex differences. The experiences of Black girls and women may be missing from interventions such as this one, and the components may not be relevant to them. Past research indicates that Black women have reported low sense of belonging among their peers and faculty, as well as feelings of cultural isolation and being excluded from informal networks such as study groups (Johnson, 2011, 2012; Malone & Barabino, 2009; Ong et al., 2011). Increasing a sense of belonging and highlighting how they can develop and integrate their social identities with their STEM identity is likely to impact STEM interest and achievement in positive ways.

The dynamics of gender can vary between racial and ethnic groups (Cole, 2009; Kane, 2000; O'Brien et al., 2015), and ranking or separating gender and racial identities makes little sense. For example, Settles (2006) suggests that Black women consider their identity as a Black-woman to be more important than either identity separately. Women of color tend to not view their race and gender separate or additive pieces of their identity, rather a unique positioning. A qualitative study by Thomas, Hacker, and Hoxha (2011) revealed that when researchers prompted discussions on experiences with race/ethnicity, and later, gender, Black women in the study responded to both prompts by recalling stories or events about being "African American women", thus underscoring that they viewed being a woman and being Black as linked. Further, Juan, Syed, and Azmitia, (2016) also found, using a college sample of mostly women of color, that Black women perceive a strong connection between their race and gender**.** Even at the turn of the century, Black women recognized the inextricable unity between their race and gender; Anna Julia Cooper (1892) famously stated in *In A Voice From the South*, "when and where I enter, in the quiet, undisputed dignity of my womanhood, without violence and without suing or special patronage, then and there the whole Negro race enters with me (p. 31)."

Without attending to the intersections, researchers would not be aware that Black girls prefer science role models to be persons of color (Buck, Cook, Quigley, Eastwood, & Lucas, 2009), or that girls from all ethnic groups, except Black girls, report higher levels of difficulty in math relative to their male counterparts (Martinez & Guzman, 2013.) Examining STEM achievement and affect over time in relation to social identities with an intersectional lens can help identify vulnerability and assets across subgroups, with the potential to inform more targeted educational policies, interventions, and practices.

The Present Study

The present study aimed to examine changes in Black girls' math and science achievement and affect across high school, and further investigate possible variations by differing levels of social group identification. This study extends our knowledge of how identity and social group membership contributes to academic outcomes in science and math during high school. Findings provide information regarding how affect and achievement in science and math change over time, and if they differ among Black girls based on social identity and SES. Further, they contribute to a better understanding of which girls need intervention help the most.

Research Questions

1. Do Black girls' math and science achievement and affect change from 10^{th} through 12^{th} grade?
2. Do changes in achievement and affect differ between math and science?
3. Do changes in math and science achievement and affect vary as a function of racial identity, gender identity, preparation for bias, and SES?

Hypotheses

Given that previous research indicates a consistent gap between girls' perceptions of their abilities in math and science and actual grades (Hyde, 2014; Petersen & Hyde, 2017; Wigfield & Eccles, 1994), it was hypothesized (*Hypothesis 1)* that the changes in math and science affect versus achievement would significantly differ, such that that math achievement would decrease and math affect would remain stable; science achievement would increase and science affect would remain stable. Generally, youth view math and science as distinct subjects, despite a degree of crossover, yet girls from all racial and ethnic backgrounds are less likely to report interest in a future math career (Riegle-Crumb, 2011). Thus, it was hypothesized (*Hypothesis 2*) that changes in science and math achievement would significantly differ, such that science achievement would increase and math achievement would decrease.

Hypotheses 3a-3e posited that changes in math and science achievement and affect would vary as a function of preparation for bias, gender identity, racial identity, and SES. Previous work provides support for a relation between parental racial socialization practices and positive academic outcomes (e.g., high educational aspirations) (Wang & Huguley, 2012), therefore *hypothesis 3a* posited that higher preparation for bias would predict increases in math/science affect and achievement over time. *Hypothesis 3b* predicted that preparation for bias would moderate the link between SES and changes in math/science achievement and affect, such that higher preparation for bias would buffer any negative effects of lower SES on math/science achievement.

Given that low SES is a risk factor for educational opportunities and achievement in science and math, it was hypothesized (*Hypothesis 3c*) that higher SES would predict increases in math/science affect and achievement. Identity centrality has been linked to positive academic outcomes (Butler-Barnes et al., 2018; Byrd & Chavous, 2011; Chavous et al., 2008; Rowley et al., 1998). Further a unique gender system within some Black families appears to support women's involvement in traditionally male dominated domains, such as science (Hanson, 2009), thus having high gender and racial centrality may be an asset for Black girls in the context of math and science. As such, it was hypothesized (*Hypothesis 3d)* that higher gender and racial identities would predict increases in math/science affect and achievement. It was additionally hypothesized (*Hypothesis 3e*) that gender and racial identities would moderate the link between SES and changes in math/science achievement and affect, such that higher race and higher gender centrality would buffer any negatives effects of low SES on math/science affect and achievement.

No specific hypotheses were made regarding differences that might manifest in these interactions between math and science, given the lack of empirical research on differences between math and science in relation to the other study variables.

Chapter III

Methodology

Dataset

Data were drawn from the Youth Identity Project (YIP), a large longitudinal study of adolescents followed from 5th through 12th grade. YIP provides a comprehensive study of Black adolescents, with an emphasis on predictors of academic success and identity development.

Participants

The present study used data from only the female adolescents collected during youth's 10th (wave 3) and 12th (wave 4) grades, given that these were the only study waves to include measures of gender identity. The sample consists of 314 Black female youth [(10th grade *M*age = 15.94 years, *SD* = 0.65; age range = 14.85-18.25 years) (12th grade *M*age = 17.81 years, *SD* = 0.49; age range = 16.76-19.5)]. Of the 314 females included in the present study, 215 were recruited in 5th grade, during wave 1 of data collection (occurred during the 2002-2003, 2003-2004, and 2004-2005 school years), and 99 were recruited in 10th grade, when the sample expanded, during the 2007-2008, 2008-2009, and 2009-2010 school years, for wave 3 of data collection. Youth attended 1 of 17 high schools in a single urban school district in the southeastern region of the U.S. The school district in which the project was conducted is in a medium-sized city in the southeastern region of the U.S. Black students made up approximately 27% to 89%

of the student populations, with a median of 69%. Students eligible for free or reduced lunch at these schools ranged from 21% to 91%, with a median of 47%.

The median yearly household income, reported by participants' parents, was between $30,000 - $39,000 [range = 'less than $10,000' (10.7%) - 'more than $100,000' (3.6%)], and median parent reported education (youth's parent and parent's spouse/partner) was 'some technical school' [range = 'less than high school' (0.5%) – 'master's degree, doctoral, or professional degree' (2%)].

Procedure

Youth and their parents were invited to participate in the study via a recruitment letter distributed directly to students who attended a participating school. Parent permission and child assent were obtained at each wave of the study. Youth completed the survey in a single 30-minute session either at school or in a public location (e.g., local public library). Participants were encouraged to read and complete the survey on their own, and a research assistant was always present to answer questions. Adolescents received a $10 gift card following completion of the survey. Parents were mailed a packet containing the parent survey with a stamped and addressed envelope to return the surveys. Following completion of the parent survey, parents received a gift card to a local grocery store and a thank-you note.

Measures

Gender Centrality. The Gender Centrality scale used was a 6-item measure adapted from the race centrality scale of the Multidimensional Inventory of Black Identity (MIBI; Sellers et al.,1998). The scale measures how central gender is to the youth's self-concept. Youth rated the extent to which they agreed with each of the six statements (e.g., Being female/male is an important part of my self-image) on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Negatively worded items were reverse coded, and the individual item scores were averaged to create a single score. A higher score indicated that gender was a more central aspect of the youth's self-concept. Reliability analyses for the subsample used indicate that the scale is moderately internally consistent (wave 3 Cronbach's alpha = .62; wave 4 Cronbach's alpha = .63).

Race Centrality. Six items from the racial centrality subscale of the Multidimensional Inventory of Black Identity (MIBI; (Sellers, Robert, Smith, Mia, Shelton, Nicole, Rowely, Stephanie, & Chavous, Tabbye, 1998) were used to assess how central being Black is to the youth's self-concept. Some items were modified to be appropriate for adolescents, and negatively worded items were dropped to improve reliability. Youth rated the extent to which they agreed with each of the six items (e.g., Being Black is an important part of who I am) on a 5-point Likert-type scale 1 (strongly disagree) to 5 (strongly agree). Individual Item scores were averaged to create a single score, and a higher score indicated that being Black was a more central aspect of the youth's self-concept. Several authors have adapted the MIBI for use with adolescents and have reported adequate internal consistency (Cronbach's αs ranging .67-.81) and discriminant validity of this measure (Hoffman, Kurtz-Costes, Rowley, & Adams, 2017; Sellers et al., 2003). Reliability analyses for the subsample used indicate that the scale is internally consistent (wave 3 Cronbach's alpha = .77; wave 4 Cronbach's alpha = .80).

Preparation for Bias. Seven items from the Hughes and Chen (1997) racial socialization measure were used to assess the frequency that youths received messages from parents about preparation for bias. Youth reported the frequency that they received specific messages (e.g., Said that people might treat you badly due to race) on a 5-point Likert-type scale 1 (Never) to 5 (More than 10 times). Reliability analyses for the subsample used indicate that the scale is internally consistent (wave 3 Cronbach's alpha = .86; wave 4 Cronbach's alpha = .89).

Socio-Economic Status (SES). Composite scores of parents' education and annual income were created by combining the target parent's education level and annual income with that of the target parent's partner/spouses' education level in waves 3 and 4. An index of the highest level of education across target parent and their partner/spouse was created (see Simpkins, Davis-Kean, & Eccles, 2005 or example). Target parents reported annual household income on a scale ranging from "less than $10,000 per year" to "more than $100,000 per year", and reported education level on a 10-point scale ranging from "less than high school" to "doctoral or professional degree." Though there is debate on how to best measure and define SES, researchers consistently agree that a combination of income and education better captures financial capital, rather than a single item alone (Duffett-Leger, Levac, Young-Morris, Watson, & Letourneau, 2011). Despite that a majority of the parents who completed the parent survey were mothers (86%), both target parents and their partner/spouse may contribute to messages about racial and gender socialization. Furthermore the highest level of education in the household likely more accurately captures the exposure that an adolescent has to various parenting practices such as racial and gender socialization messages, as well as the activities that a parent emphasizes as important. Education level may have implications for the types and content of conversations that parents are having with their adolescents.

Math/Science Affect.

Math/Science Interest and Expectations. To assess interest level and future expectations in math and science separately, youth were asked to respond to 3 items, "How interested are you in the material you learn in your Math [Science] class" (1 = Not at all interested; 5 = Very interested),"In the future, how likely are you to enroll in an Honors or Advanced Placement class in Math [Science][1]" (1 = Not at all likely; 5 = Very likely), "How likely are you to pursue a career in Math [Science]" (1 = Not at all likely; 5 = Very likely). Intentions to take advanced coursework in math. In 10th grade, youth responded to an item asking, "How likely are you to pursue advanced coursework in math?" (1 = Not at all likely; 5= Very likely). Intentions to pursue a career in math. In 10th grade, youth responded to an item asking, "How likely are you to pursue a career in math?" (1 = Not at all likely; 5 = Very likely). Reliability analyses for the subsample used indicated that the scale is internally consistent (Math wave 3 Cronbach's alpha = .72; Math wave 4 Cronbach's alpha = .73; Science wave 3 Cronbach's alpha = .76; Science wave 4 Cronbach's alpha = .76).

Math/Science Classroom Engagement. Youth ranked their classroom engagement in science and math classes using a 14-items adapted from a measure created by Skinner and Belmont (1993), which was developed to assess classroom engagement and re-engagement after failure. Youth rated the extent to which they

[1] Note: this question was not asked in 12th grade (wave 4) given it was no longer relevant.

agreed with the 14 statements (e.g., If a science assignment is really hard, I keep working on it) on a 5-point Likert-type scale, 1 (strongly disagree) to 5 (strongly agree). Reliability analyses for the subsample used indicated that the scale is internally consistent (Math wave 3 Cronbach's alpha = .76; Math wave 4 Cronbach's alpha = .80; Science wave 3 Cronbach's alpha = .77; Science wave 4 Cronbach's alpha = .72).

Math/Science Perceived Competence. Youth ranked their competence in science and math compared to their peers by circling a figure in a column of twenty-five stick figures (Nicholls, 1978[2]). Anchors at the top and bottom of each item were "*The best*" and "*The worst*," respectively. Items were scored according to the child's ranking (i.e., from 1 to 25), with higher scores indicating greater perceived competence.

Math/Science affect scores were created by averaging scores from the three measures described above – *Math/Science Interest and Expectations*, *Math/Science Classroom Engagement*, and Math/Science Perceived *Competence*. Because the measure were on different scales, the raw scores were first converted to z-scores and then averaged to create math and science affect scores. Reliability analyses for the subsample used indicate that the scales are internally consistent (Math Affect wave 3 Cronbach's alpha = .79; Math Affect wave 4 Cronbach's alpha = .84; Science Affect wave 3 Cronbach's alpha = .81; Science Affect wave 4 Cronbach's alpha = .81).

Math/Science Achievement. End of course grades for science and math were obtained from school records. The course grades were averaged to create a composite

[2] Nicholls JG. The development of the concepts of effort and ability, perception of academic attainment, and the understanding that difficult tasks require more ability. Child Development. 1978;49:800–814.

score of achievement, resulting in average science and math grades for 10th grade and 12th grades, respectively.

Math/Science Achievement Change Scores. Achievement change scores were calculated for math and science separately by subtracting the average end of math course grade in 10th grade from the average end of math course grade in 12th grade, and by subtracting the average end of science course grade in 10th grade from the average end of science course grade in 12th grade.

Change scores, also known as difference scores, were one of the earliest methods used to analyze data across time points (Thomas & Zumbo, 2012). Some have criticized the use of this method given its susceptibility to reliability issues, and advocate for the use of residualized change scores instead (Castro-Schilo & Grimm, 2018), however, there are merits of using change scores. First, change scores are less influenced by baseline differences (Thomas & Zumbo, 2012), which were present in this sample and not due to a priori differences (i.e., age or sex). Next, the sample had adequate variability between individuals; that is achievement and affect in waves 3 and 4 were not highly correlated, thus providing adequate power for testing (Castro-Schilo & Grimm, 2018).

Math/Science Affect Change Scores. Affect change scores were calculated for math and science separately by subtracting the math affect score in 10th grade from the math affect score in 12th grade, and by subtracting the science affect score grade in 10th grade from the science affect score in 12th grade.

Data Analytic Plan

Prior to conducting analyses, descriptive statistics were obtained to increase familiarity with the data and check assumptions. Due to non-normal distributions, some variables required transformations. For math affect in waves 3 and 4, the cube root transformation was used, for math grades in waves 3 and 4 the log transformation was used, and for science grades in waves 3 and 4 the log transformation was used. To examine potential mean changes in math and science affect and achievement from 10^{th} to 12^{th} grade (research questions 1-2), paired sample t-tests were conducted. To examine potential moderating effects of gender centrality, racial centrality, preparation for bias, and SES on changes in math and science affect and achievement (research question 3), linear regressions were conducted.

Descriptive statistics and paired t-tests were conducted using SPSS version 25 (IBM Corporation, 2019). Multiple linear regressions (MLR) were conducted using Mplus version 8.2 (Muthén & Muthén, 2018). To account for missing data, full information maximum likelihood (FIML) was used, given that this technique maximizes the use of existing data points without listwise or pairwise deletion (Muthén & Muthén, 2010).

Moderate to high levels of missingness were found among the study variables. For 10^{th} grade math achievement, 10 students' data were missing either because they had partial data or were not taking the particular course. For 12^{th} grade math achievement, 6 students' data were missing because they were not taking that particular class and 12 students were taking the class but their data was missing for an unknown reason. For 10^{th} grade science achievement, 22 students' were not taking the class and 5 had only partial data. For 12^{th} grade science achievement, 2 participants were not taking the class, 1 participant was done with her requirements, and 22 were taking the class but had missing data for an unknown reason. In addition, data were missing because participants did not respond to individual items on their surveys and attrition, thus resulting in levels of missingness ranging from 25.8%-60.2%.

As recommended by Aiken and West (1991), continuous variables (Gender Centrality, Race Centrality, and Preparation for Bias) were mean centered prior to analyses. Moderator variables were multiplied together to create a series of 2-way interaction terms:

Gender Centrality x Race Centrality

Gender Centrality x Preparation for Bias

Gender Centrality x SES

Preparation for Bias x Race Centrality

Preparation for Bias x SES

Race Centrality x SES

Preparation for Bias x SES

In order to probe statistically significant interaction effects, the online tool created by Preacher, Curran, and Bauer (2006) was used. This tool provides significance tests for simple slopes of the relation between the predictor and dependent variable at specified values of the moderator. Values used in the simple slopes analysis were calculated to be 1 standard deviation above the mean, at the mean, and 1 standard deviation below the mean (Aiken & West, 1991). An alpha level of .05 was used in all analyses.

Chapter IV

Results

Descriptive Statistics

Prior to conducting the main analysis, the means, standard deviations, and intercorrelations of participant characteristics and study variables were calculated to increase familiarity with the dataset and provide a point of comparison for past and future studies.

Demographic variables. In wave 3, youth were in 10th grade and were between the ages of 14.85-18.25 years (*M*age = 17.81 years, *SD* = 0.65). In wave 4, youth were in 12th grade and were between the ages of 16.76-19.5 (*M*age = 17.81 years, *SD* = 0.49). Youth attended 1 of 17 high schools within one urban school district in the southeastern region of the United States. The median yearly household income, reported by youths' parents, was between $30,000 - $39,000 [range = 'less than $10,000' (10.7%) - 'more than $100,000' (3.6%)], and median parent reported education (youth's parent and parent's spouse/partner) was 'some technical school' [range = 'less than high school' (0.5%) – 'master's degree, doctoral, or professional degree' (2%)].

Study variables and Correlations. Pearson Correlations for all study variables appear in Table 1. Table 2 provides descriptive statistics for study variables collapsed across SES. Table 3 Includes descriptive statistics for affect and achievement across

SES groups by grade level. Table 4 provides descriptive statistics for study variables by SES. Finally, Table 5 has descriptive statistics for affect and achievement by SES and grade level.

Research Question 1. *Do Black girls' math and science achievement and affect change from 10th through 12th grade?*

Paired sample t-tests revealed that girls in this sample had a statistically significant decrease in math achievement ($t(136) = 5.80$, $p = .001$) and an increase in science achievement ($t(97) = -31.52$, $p = .001$) from 10th to 12th grade; whereas there were no significant changes in math ($t(54) = -0.16$, $p = .876$) and science affect ($t(219) = 0.87$, $p = .385$) from 10th to 12th grade.

Research Question 2. *Do changes in achievement and affect differ between math and science?*

Paired sample t-tests revealed that, changes in math ($M = -.13$, $SD = .31$) and science achievement ($M = 1.73$, $SD = 8.94$) did not significantly differ, $t(84) = 1.85$, $p = .067$. Similarly, changes in math ($M = -.04$, $SD = .73$) and science affect ($M = -.04$, $SD = .41$) did not significantly differ, $t(156) = 0.03$, $p =.977$.

Research Question 3. *Do changes in math and science achievement and affect vary as a function of racial identity, gender identity, preparation for bias, and SES?*

Math achievement changes

For math achievement change, there was a significant main effect of SES ($\beta = .28$, $SE = .12$, $p = .023$); such that increases in SES predicted increases in math achievement. A significant interaction between gender centrality and racial centrality was found ($\beta = -.32$, $SE = .16$, $p = .045$), see Figure 1, such that the relationship between higher gender centrality and decreases in math achievement was strongest for girls with higher racial centrality and weakest for those with lower racial centrality. The relationship between lower gender centrality and decreases in math achievement was strongest for girls with lower racial centrality and weakest for girls with higher racial centrality. The interaction was probed by testing the conditional effects of gender centrality at three levels of racial centrality, one standard deviation below the mean, at the mean, and one standard deviation above the mean. This indicated that for the interaction between race centrality and gender centrality, none of the simple slopes significantly differed from zero, low (β = .12, *SE = .18, p* = .50) moderate (β = -.11, *SE = .15, p* = .47) high (β = -.34, *SE = .19, p* = .09) .

A significant interaction was also found between gender centrality and SES (β = -.36, *SE = .15, p* = .016), see Figure 2, such that the relationship between higher SES and increases in math achievement was strongest for girls with low gender centrality, weakest for girls with moderate gender centrality, and girls who reported higher gender centrality demonstrated decreases in math achievement. The relationship between lower SES and decreases in math achievement was strongest for girls with lower gender centrality and weakest for girls with high gender centrality. The interaction was probed by testing the conditional effects of gender centrality at three levels of SES, one standard deviation below the mean, at the mean, and one standard deviation above the mean. This indicated that the interaction significantly differed from zero at high (β = -.89, *SE* = .36*, p* = .016), but not low (β = .68, *SE = .35, p* = .059) and moderate (β = -.11, *SE = .15, p* = .473) levels of gender centrality.

Science achievement changes

For science achievement change there was a significant main effect of racial centrality (β = -.35, *SE = .14, p* = .015), such that increases in racial centrality predicted decreases in science grades. A significant interaction was found between preparation for bias and SES (β = .44, *SE =.18, p* = .016), see Figure 4, such that the relationship between higher SES and increases in science achievement was strongest for girls with higher preparation for bias and weakest for those who had lower preparation for bias. The relationship between lower SES – among the lower SES girls, increases in science achievement were higher for those who reported lower preparation for bias relative to higher preparation for bias. The interaction was probed by testing the conditional effects of preparation for bias at three levels of SES, one standard deviation below the mean, at the mean, and one standard deviation above the mean. The interaction between SES and preparation for bias significantly different from zero at low (β = -.59, *SE = .*22*, p* = .010), but not moderate (β = -.15, *SE = .15, p* = .317) or high (β = .29, *SE = .*25*, p* = .243) levels of preparation for bias.

Math affect changes

For math affect change, there was a significant interaction between gender centrality and SES (β = 0.37, *SE* = .18*, p* = .038), see Figure 5, such that the relationship between higher SES and decreases in math affect was stronger for girls who had lower gender centrality and weaker for girls who had moderate gender centrality. Higher SES girls who reported higher levels of gender centrality demonstrated stability in math affect over time. The relationship between lower SES and increases in math affect were strongest for girls with lower gender centrality and weaker for those with moderate levels of gender centrality. Lower SES girls who reported higher gender centrality demonstrated declines in math affect over time. The interaction was probed by testing the conditional effects of gender centrality at three levels of SES, one standard deviation below the mean, at the mean, and one standard deviation above the mean. The interaction between gender centrality and SES significantly differed from zero at low (β = -.80, *SE* = .42, *p* = .054) and high (β = .79, *SE* = .40, *p* = .052), but not moderate (β = -.01, *SE* = .14, *p* = .945) levels of SES.

Science affect changes

For science affect change, a significant interaction was found between gender centrality and racial centrality (β = 0.31, *SE* = .12, *p* = .010), see Figure 6, such that the relationship between higher gender centrality and increases in science affect was strongest for girls with higher racial centrality, Girls with higher gender centrality and weaker moderate levels of racial centrality demonstrated stability in affect over time, and those with higher gender centrality and lower levels of racial centrality demonstrated declines in science affect over time. The relationship between lower gender centrality and decreases in science affect was strongest for girls with higher levels of racial centrality, weaker for those with moderate racial centrality, and weakest for girls with higher racial centrality. The interaction was probed by testing the conditional effects of gender centrality at three levels of racial centrality, one standard deviation below the mean, at the mean, and one standard deviation above the mean. The interaction between gender centrality and racial centrality was only significantly differed from zero at high β = .37, *SE* = .15, *p* = .016), but not low (β = -.08, *SE* = .13, *p* = .533) and moderate β = .15, *SE* = .11, *p* =.198) levels of race centrality.

Chapter V

Discussion

The purpose of this study was to identify if and how math and science achievement and affect change for Black girls throughout high school. In addition, it examined if these changes varied as a function of social identity variables, preparation for bias, and SES, reasoning that some social identities and backgrounds may be advantageous for girls in the context of typically male stereotyped domains. The focus on social identities and socialization is important in light of previous research indicating the link between socialization within Black families and Black girls' more positive attitudes and less stereotypical thinking toward math and science (Hanson, 2004a, 2006, 2009; O'Brien, Blodorn, et al., 2015). Moreover, previous research has not tested how SES might interact with different levels of social identities to impact changes in achievement and affect in math and science over time.

The sample consisted of 314 Black female students in the 10th and 12th grades from 17 different high schools in the southeastern region of the U.S. Overall, findings suggest that the combination of different levels of a given social identity and socialization do impact changes in math and science affect and achievement across high school in meaningful ways. Evidence from this study also reveals that SES differentially impacts girls' math and science affect and achievement over time based on the identities that they hold. Lastly, study findings illustrate the utility of considering how race in combination with gender plays a dynamic role for Black girls in the context of math and science outcomes.

Summary of findings

Does math and science achievement and affect change from 10th to 12th grade?

It was hypothesized that science achievement would increase, math achievement would decrease, and affect in both subjects would either remain stable or decrease. This was supported, as increases in science achievement were observed, and math achievement decreased over time. The finding that science achievement increased is consistent with previous studies indicating that many girls experience increases in science achievement (Larose, Ratelle, Guay, Senécal, & Harvey, 2006; Muller et al., 2007), and the body of work suggesting that Black girls are especially interested in science (Hanson, 2006, 2007, 2009). The finding that math achievement decreased over time is not surprising given that many other studies have found a sharp decline in girls' math achievement from middle school to high school (Eccles et al., 1993; Shapka, 2009). Both math and science affect remained relatively stable from 10th to 12th grade, as mean scores did not significantly differ between the two time points. The finding that math affect remained stable is somewhat inconsistent with previous work which has demonstrated a decline in math affective variables for girls. It should be noted, however, that most of the studies rely heavily on White samples. The finding that science affect remained stable is consistent with previous work indicating variation among youth's trajectories in science affect (Wang, Chow, Degol, & Eccles, 2017).

Science, in contrast to math, appears to be more accessible for girls in this sample, in light of increases in science achievement from 10th to 12th grade. Distinctions between the two subjects seem to be predominantly driven by changes in achievement, but not affect. Results of this study corroborate past research which has found there tends to be a gap between girls' perceptions of their abilities and actual achievement (Hyde, 2014; Petersen & Hyde, 2017; Wigfield & Eccles, 1994). Current study findings suggest that Black girls in this sample experienced increases and decreases in their math and science achievement, but their affect in these subjects does not appear to consistently change in the same direction. Though affect and achievement tend to influence one another, this may not be the case for all girls.

Do changes in achievement and affect differ between math and science?

The hypothesis that changes in science achievement would be larger relative to changes in math achievement was unsupported. Changes in math and science achievement did not significantly differ from one another, but were trending ($p = .06$), as changes in science achievement were larger in magnitude relative to changes in math achievement, and this was consistent between SES groups. The observed changes in science were increases and the changes in math were decreases, which is consistent with previous studies which suggest that math achievement tends to decline over time (Eccles et al., 1993; Shapka, 2009) but for science achievement there much more variation (Larose et al., 2006; Muller et al., 2007). Despite Black girls' positive attitudes toward science, achievement declines in science were present in this sample. Future research is needed to determine what factors contribute to declines in Black girls' math and science attitudes specifically during high school. Given that Black girls are socialized to be strong and independent, this may reduce engagement help-seeking behaviors when they reach obstacles in science courses. Without having external resources to take on academic challenges, these girls may experience declines in motivation and disengagement in science. Additionally, it is also possible that other interests that develop during the transition from 10th to 12th grade may deter continued interest in science.

As hypothesized, changes in math and science affect did not differ. Previous research, with mostly White samples, indicates that math affect tends to decline with time (Fredricks & Eccles, 2002; Sadler et al., 2012), and there is more variability with science affect (Hanson, 2009; Wang & Degol, 2017). This suggests that girls in the present sample maintained their attitudes toward science and math, despite changes in their grades in these subjects. Typically, affective variables and academic achievement are highly correlated, thus future research should consider exploring possible variation among girls.

Do changes in math and science achievement and affect vary as a function of racial identity, gender identity, preparation for bias, and SES?

Math achievement

A main effect of SES was found, indicating that a higher SES predicted increases in math achievement. This is consistent with the large body of adolescent research suggesting a link between SES and academic outcomes (Hrabowski et al., 2002; Maton et al., 2000; Xie et al., 2015). Youth from higher SES families tend to have more access to academic resources, such as tutoring (Hrabowski, Maton, Greene, & Greif, 2002; Maton, Hrabowski, & Schmitt, 2000), which likely help to bolster gains in their academic achievement.

The hypothesis that girls who reported higher gender centrality would buffer any negative effects of lower SES on changes in math achievement was supported. Regardless of SES, low and high SES girls demonstrated declines in math achievement, with the exception of higher SES girls who reported low gender centrality. In support of the hypothesis, among lower SES girls, those with high gender centrality demonstrated the smallest declines. Among high SES girls, the only group to demonstrate declines were those who reported high gender centrality. Conceptualizations of gender for high versus low SES girls appear to vary in important ways—that is, gender centrality seems to be beneficial for some, but not all girls. Despite that high SES families tend to endorse more egalitarian gender roles (Marks, Lam, & McHale, 2009), there is some evidence suggesting that some high SES families promote behaviors and activities that are more gendered (Lubienski et al., 2013). Limited exposure to science and math outside of the classroom and fewer opportunities to practice in math-linked skills, such as spatial reasoning, disadvantage girls in subjects that require quantitative skills. Further, research indicates that low SES men and women, and high SES men make similar college major selections; whereas high SES women are more likely to select a major that yields fewer economic returns (Ma, 2009b; Mullen, 2014). Thus, high SES alone, does not automatically yield greater educational gains.

Science achievement

The hypothesis that gender and racial identities would predict increases in science achievement was unsupported. No main effects of gender centrality were found and a main effect of racial centrality was found, such that increases in race centrality predicted declines in science achievement. This finding is juxtaposed to past research indicating a link between higher race centrality in youth and academic achievement (Bowen, Hopson, Rose, & Glennie, 2012; Brown & Bigler, 2005; Brown & Chu, 2013; Rivas-Drake et al., 2014; Seaton & Sellers, 2016), suggesting that high racial centrality can be beneficial for youth. It may be that the association between high racial centrality and positive academic outcomes does not apply in science. This finding may also have emerged because at this age youth are still exploring their identities. Given that identities do not always develop simultaneously (Flum, 1994; Kunnen, Sappa, Van Geert, & Bonica, 2008) some girls may put more emphasis on racial and gender identity self-exploration during this time, therefore lessening interest and self-exploration in academic domains.

The hypothesis that girls who reported more preparation for bias messages would demonstrate increases in math and science affect and achievement was unsupported. It might be the case the more preparation for bias is harmful for girls in this sample, as this increased awareness may cause them to internalize some of the negative messages they receive from others. The hypothesis that higher preparation for bias would buffer any negative effects of lower SES on science achievement was supported. A significant interaction between preparation for bias and SES revealed that lower SES girls with lower preparation for bias demonstrated the largest increases in science achievement; whereas higher SES girls with lower preparation for bias demonstrated the smallest increases. It should also be noted that higher SES girls with higher levels of preparation for bias had the second largest increases. This suggests that, in the context of changes in science grades, the higher a girls' SES is the more she benefits from preparation for bias messages; whereas the lower her SES is the less beneficial that preparation for bias may be. Black adults from low income backgrounds tend to perceive less discrimination relative to their higher SES counterparts (Williams, 1999). Blacks with a higher SES are more likely to have frequent and consistent contact with individuals from other racial groups, thus increasing their chances of exposure to racially discriminatory experiences (e.g., in the workplace) which may explain why parents are more likely to engage in preparation for bias messages with their children if they, personally, experience high levels of discrimination themselves (Gibbons, Gerrard, Cleveland, Wills, & Brody, 2004; Sigleman & Welch, 1991). Perhaps more preparation for bias messages for low SES Black girls in this sample produces a hyper awareness of negative stereotypes about their social group and discrimination in their environment, thus leading them to internalize these ideals, and experiences demotivation in academics. More preparation for bias messages among higher SES girls may empower them in ways that are motivating. This findings builds upon previous research findings indicating that girls who learned about gender discrimination science were more likely than a control group to increase their self-efficacy in science (Weisgram & Bigler, 2007), perhaps future research just needs to examine if there is variation among girls from different SES groups.

It is important to note, however that in contrast to math achievement, there were no main effects of SES on changes in science achievement. This is unexpected given the large body of research indicating links between SES and educational outcomes for youth (Hrabowski et al., 2002; Maton et al., 2000; Xie et al., 2015). It could be that when academic achievement as an aggregate is examined, SES plays an important role, but for domain specific achievement different patterns may emerge, such that SES is more important for outcomes in math relative to science during high school. This may be because math concepts build upon one another, such that without the foundations it becomes increasingly difficult to continue acquiring more complex math skills. However, science courses taught during high school are somewhat more isolated from one another. For example, courses such as physics do not require preexisting knowledge of biological concepts.

Math affect

The hypothesis that higher gender centrality would buffer any negative effects of low SES on math affect was unsupported. Consider gender as important may not be protective for low SES girls in the context of changes in math affect during high school because they may have strong associations between gendered academic stereotypes about math. The significant interaction between SES and gender centrality revealed that higher SES girls with either moderate or lower gender centrality demonstrated declines in math affect, and those with high gender centrality experienced stability. Lower SES girls with low gender centrality demonstrated the highest increase in math affect, those with moderate levels of gender centrality demonstrated the smallest increase, and those with high gender centrality exhibited decreases. Unexpectedly, among lower SES girls, low gender centrality seemed to have a buffering effect. However, the opposite pattern emerged for higher SES girls, wherein, having high gender centrality produces stability rather than declines in math affect. Current literature suggests a link between gender centrality and positive outcomes for females (e.g., Saunders & Kashubeck-West, 2006; Settles et al., 2009, 2016; Yakushko, 2007), but this may only be true for high SES

Black girls. Previous research indicates that what it means to be a woman varies by race and ethnicity (Settles, 2006), but possible variations in what it means to be a woman have not been identified by SES. Black girls are taught to place less emphasis on traditional definitions of womanhood (Buckley & Carter, 2005; Hill, Studies, & Mar, 2001), and high SES girls are sometimes taught to engage in more traditionally stereotypical activities and behaviors (Lubienski et al., 2013), perhaps regardless of race. Thus, building identity around a strong sense of gender, could be useful for high SES girls and less productive for low SES girls. However, for girls who are socialized in an environment wherein gender is emphasized, a strong gender identity may help to mitigate negative stereotypes in domains where they might perceive more discrimination relative to their lower SES counterparts. Future research might consider investigating how Black girls from different SES groups conceptualize what it means to be a girl.

Science affect

Similar to math affect, the hypothesis that higher gender centrality would buffer any negative effects of low SES on science affect was unsupported. This finding may have emerged because definitions of what it means to be a girl or woman may differ by SES, and perhaps lower SES girls do not consider this identity helpful in academic domains such as science. Instead, a significant interaction was found between race and gender centrality, revealing that the only girls who experienced increases in science affect where those who had high levels of both gender and racial centrality, and all other girls demonstrated either declines or stability in math affect. The largest declines were among girls who had lower gender centrality and high racial centrality, and the smallest declines were among those who had low gender centrality and low racial centrality. Collectively, this suggests that the level of importance placed on racial and gender identities differs among Black girls in this sample, and the different combinations have implications for changes in their science affect across high school. Self-perceptions of identity are not the same among all girls, thus future research should continue to probe how gender and racial identity in tandem are conceptualized among Black girls. Further, examining this in younger samples would provide insights regarding how these conceptualizations potentially change or remain stable over time.

Not all individuals view their race and gender as equally important, nevertheless a body of literature indicates that there are positive outcomes associated with having value for one's social identities. For example, a sense of social group membership can buffer the negative impacts of discrimination, increase awareness of environmental bias against social groups, and increase academic achievement (Bowen et al., 2012; Brown & Bigler, 2005; Brown & Chu, 2013; Rivas-Drake et al., 2014; Seaton & Sellers, 2016), Using cluster analysis, Brown et al (2011) found that most youth rate both their gender and racial identities as high, or both as low, which may help explain why changes in science affect were highest for girls who reported either high on both identities or low on both identities. Furthermore, in this sample, Black girls who reported being high on both or low on both identities also reported the most incidences of being a witness or target of both ethnic and gender bias relative to youth who reported being high on one identity and low on the other. Perhaps Black girls who are more aware of bias in their environments use these events to propel themselves in domains where negative stereotypes and bias are prevalent as a way to negate the bias. Girls in the present study who reported high race and high gender centrality were the only group to experience increases in science affect, thus demonstrating that valuing both social groups may be protective in some capacity. Perhaps by playing a buffering role via increases in a sense of group belonging.

Putting it all together

Study findings in contrast to one another indicate a high degree of variation among the girls in this sample. Differences between affect and achievement were evident, as well as differences between science and math.

In science there is a high degree of variability with respect to change; some girls experienced increases, others declines, and some stability. In math, increases are unlikely to occur, some stability does occur, and any increases are very minimal. These findings contribute to the growing body of literature documenting differences between STEM subjects. Despite a degree of overlap, science and math are different subjects that ultimately present different information and have different stereotypes associated with them. As such, girls' perceptions and achievements in these subjects also vary.

For affect, changes that occurred were predominately declines, and any increases were very small in magnitude. For achievement, there was a higher degree of variability in the changes that took place. Though affect and achievement are often positively correlated and mutually influential (Eddy & Brownell, 2016; Else-Quest et al., 2010), there are instances in which girls in this sample were high on one and low on the other. This, however, is not surprising given past research indicating that girls and low income youth often demonstrate a gap between their attitudes toward and science and math and actual grades in these subjects (Catsambis, 1995; Hyde, 2014; Petersen &

Hyde, 2017; Riegle-Crumb et al., 2011; Wigfield & Eccles, 1994). Unfortunately, this means that increasing affect does not always lead to increases in achievement, and vice versa.

The transition from 10th to 12th grade is a developmentally important time to examine how identity in relation to academic outcomes given the importance of identity exploration during this time. Beyond this developmental task, there are a host other changes that occur during this time. For example, by the end of high school girls are either preparing enter high education or the labor force. Additionally by the end of high school more external pressures may be present, such as expectations from family to attend college and possibly having to finance all living expenses on one's own. These social and psychological changes likely work in tandem with the current study variables to contribute to the observed declines and increases in science and math.

Attributes that Black girls are socialized to adopt, such as being independent and assertive, are also associated with success in STEM domains. However, Black girls still experience a host of barriers to participation in STEM. Firstly, these traits may be promotive of achievement in science and math, but other aspects of Black girls' socialization could impede help-seeking behaviors when challenges are met in these subjects. Second, as girls they are very aware of and impacted by stereotypes about girls' abilities in science and math. And third, as Black individuals they are still impacted by societal power structures that limit educational opportunities for Black youth.

Limitations

The present study included many strengths, such as the use of longitudinal data, an intersectional approach including gender, race, and SES, and comparisons of science and math. Limitations, however, were present. Frist, two data points were used, thus limiting analyses to only testing linear relationships among study variables. Additionally, caution should be taken when generalizing findings to the broader population. This sample came from a school district in the southeastern region of the U.S. that has a long history of prominent and wealthy Black Americans. Further, Black students comprised a majority of the students in many of the schools that these girls attended. A number of cities in the U.S. do not benefit from a strong representation of Black individuals, thus findings in the present study may be unique to this sample. Black girls in other regions of the U.S. may experience different levels identity centrality. For example, Black girls who reside in areas with a very small Black population may have lower levels of racial centrality relative to those in this sample, which could have implications for their academic motivation and engagement in science and math.

Implications for Practice and Research

The current study advances the literature by incorporating an intersectional approach to mapping out changes for Black girls in high school in math and science. It offers a number of theoretical and practical implications. Previous research has examined how variables such as math motivation, math identity, and math self-concept change over time (e.g., Peterson & Hyde, 2015), however most work has addressed differences between boys and girls rather than within group variation among girls. Moreover, no studies (to date) have examined how the associations among STEM affective variables (e.g., interest, expectations) and achievement (e.g., grades) might vary by racial and gender identities, socialization, and socioeconomic status. Lastly, work on this topic is typically limited to testing one domain at a time (for exception see Guo et al., 2018) instead of providing comparisons between STEM subfields.

Study findings demonstrate that changes in science and math affect are somewhat similar across high school, though for science and math achievement are more different than similar. Therefore, if a goal is to alter math or science achievement, intervention work should consider treating math and science as separate domains. Findings provide evidence of a dynamic interplay between SES, identity variables, and achievement/affect in math/science for Black girls. In light of this, future that include girls of color should consider how to incorporate racialized gender identity. Lastly, given the potential impact of gender and racial socialization on academic help-seeking, framing academic help-seeking behaviors as a strength could be beneficial.

Future research might consider extending this project to follow Black girls from early high school to late adolescence. It would have been useful to see how relations among the study variables developed during and post high school. Following girls' as they move into the workforce and higher education would yield insights into how their social identities influence changes as they make educational decisions that likely shape their lives in important ways. This would allow for assessment of how affect and achievement in high school influence future educational decisions. Additionally, there should be a more in-depth focus on how SES works in tandem with social identities to inform educational outcomes for Black girls. While there is a large body of research that has focused on how SES more generally influences educational achievement for low income youth and URM youth, there is seldom scholarly research that focuses solely on Black girls in the context of education, let alone science and math. Qualitative work may be especially helpful in setting the foundations for larger scale studies. Lastly, there may be unique benefits of coming from a low income family, thus future scholarly work should adopt a strengths-based framework that explores the how intersection of race and gender for Black girls from different SES levels contributes to educational achievement.

While there is a great deal of research on girls and women in STEM, there is a dearth of research on girls and women in STEM that makes comparisons between STEM subfields. It is important to separate out these domains because youth consider them to be distinct. Another avenue for research and practice is to reframe how identities are conceptualized for non-white women in STEM fields. Scholarly work on Black women and education tends to describe their experiences as a “double disadvantage” or “double bind” (O’Brien, Garcia, et al., 2015), however there are situations in which certain social identities may be advantageous for Black women. For example, in domains that harbor bias, wherein the socialization that many Black families report engaging in yields traits that are beneficial.

Concluding Thoughts

Black girls are often left out of the discussion on girls in STEM, yet they have experiences that may bolster their success in science and math. This study used an intersectional framework to extend past research on Black girls in STEM by examining how girls’ outcomes in science and math during high school vary by factors related to socialization and identity. Findings from the present study have implications for interventionists, scholars, educators, families, and most importantly, high-school aged girls. This study highlights two important points that should be considered in continued efforts to increase diversity in STEM fields. First, STEM is more than just an aggregate, as it encompasses a variety of fields and professions, and some of these fields see far fewer women relative to others. Increased emphasis at the subject level will be increasingly critical, particularly for interventions for girls in the K-12 population. Second, girls need to be made more aware of the variety of options available within STEM fields. Given that many girls, regardless of race, report an interest in helping fields, increased efforts to demonstrate how many fields, even those typically not associated with social good, benefit society.

Diversity in STEM fields is a persistent problem, but it is not an issue that has to remain stagnant. Policies and practices can change over time, but this all begins with awareness and changes in perceptions and attitudes. Asking the right questions and being targeting in the intervention work is critical, as is providing something very basic - opportunity. Mae Jemison, former NASA astronaut said it well, “We look at science as something very elite, which only a few people can learn. That’s just not true. You just have to start early and be given a foundation. Kids live up, or down, to expectations”.

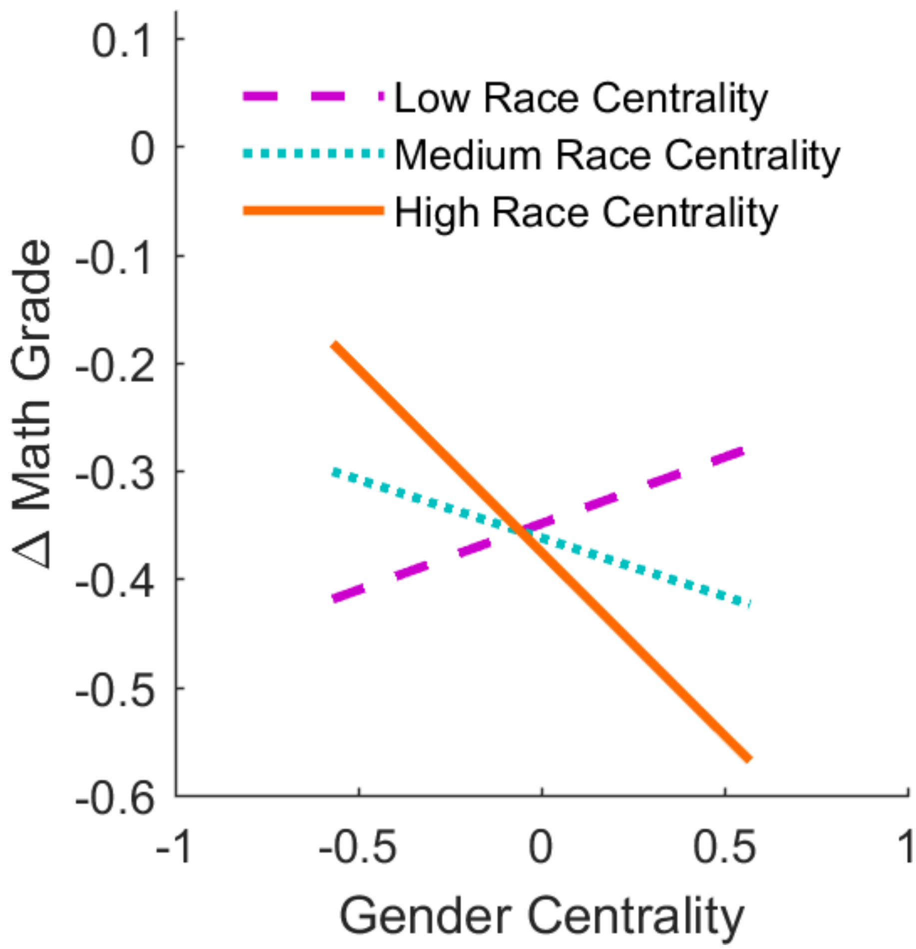

Figure 1. Math achievement change as a function of gender centrality and race centrality.

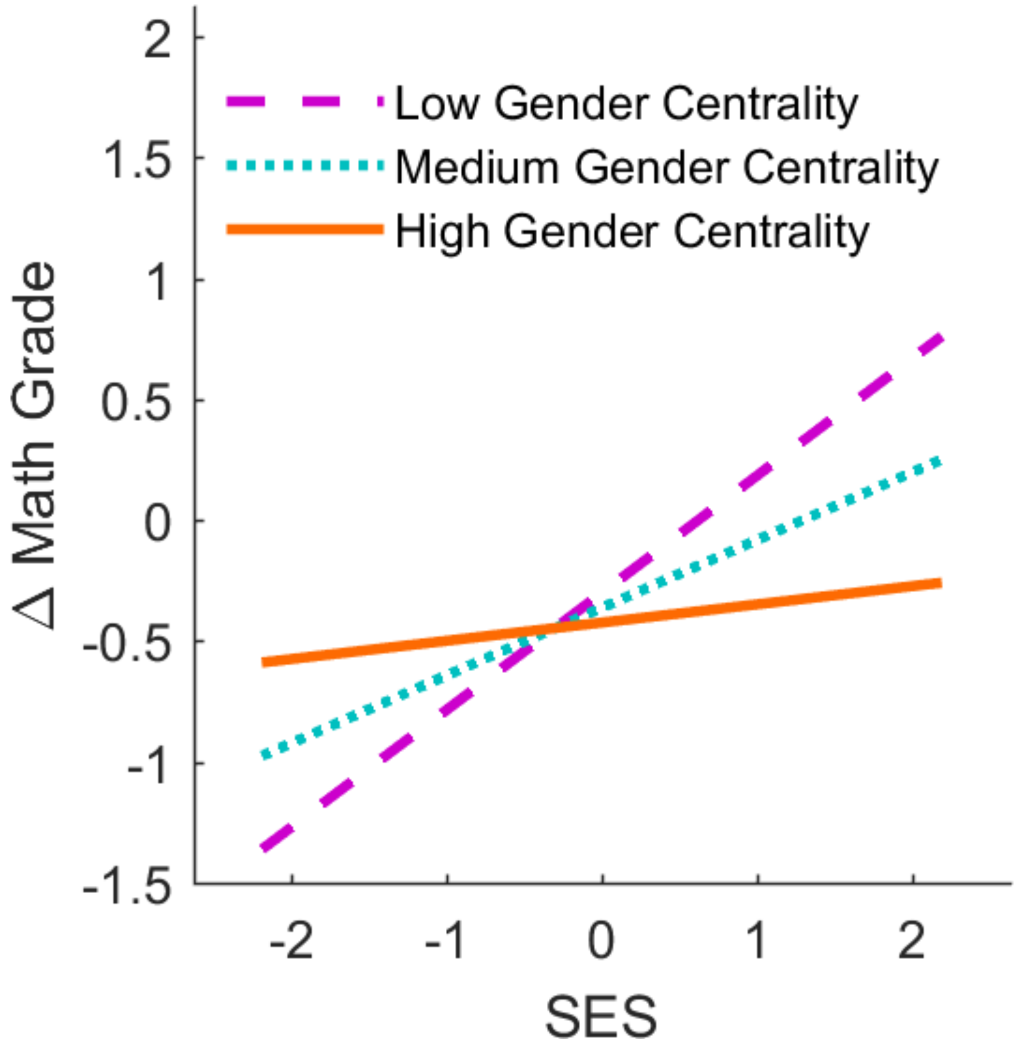

Figure 2. Math achievement change as a function of gender centrality and SES.

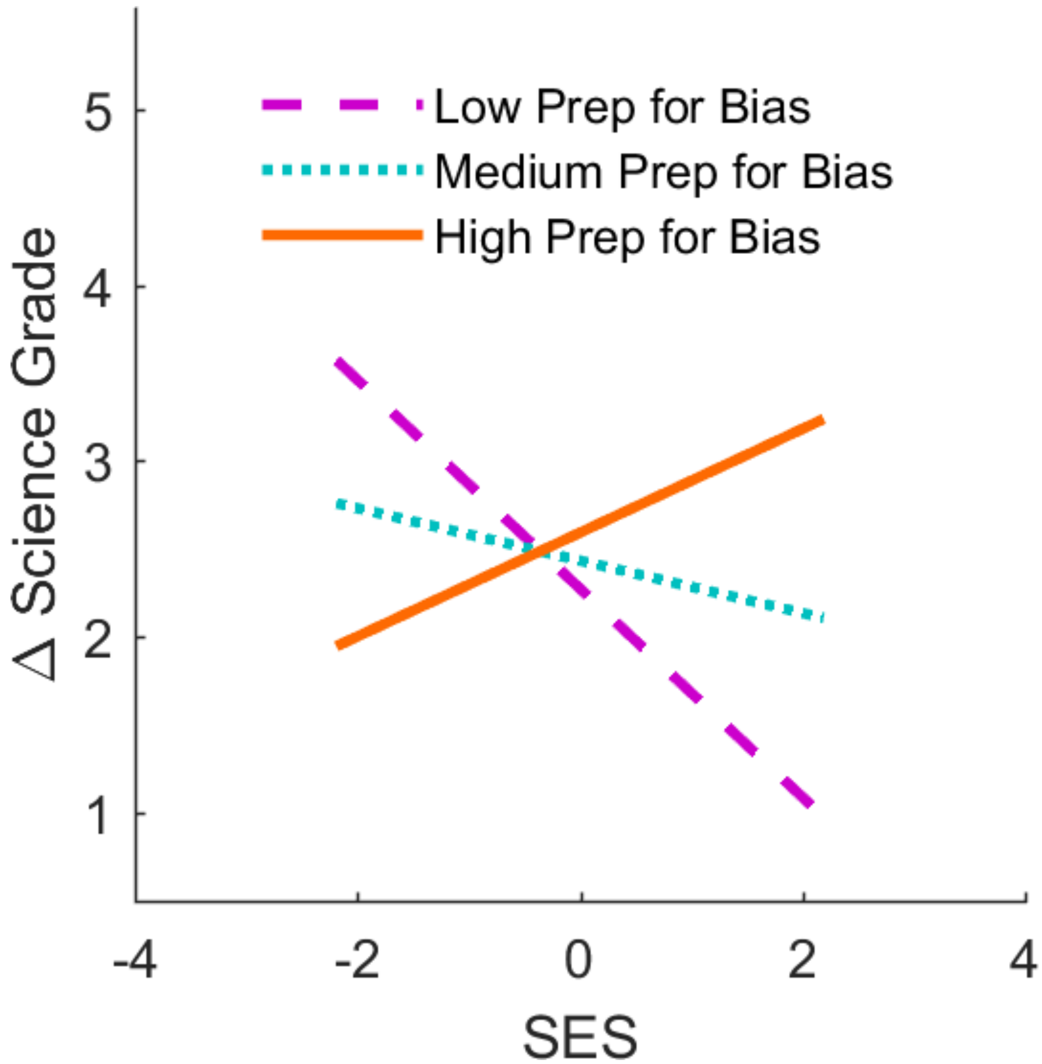

Figure 3. Science achievement change as a function of SES and preparation for bias.

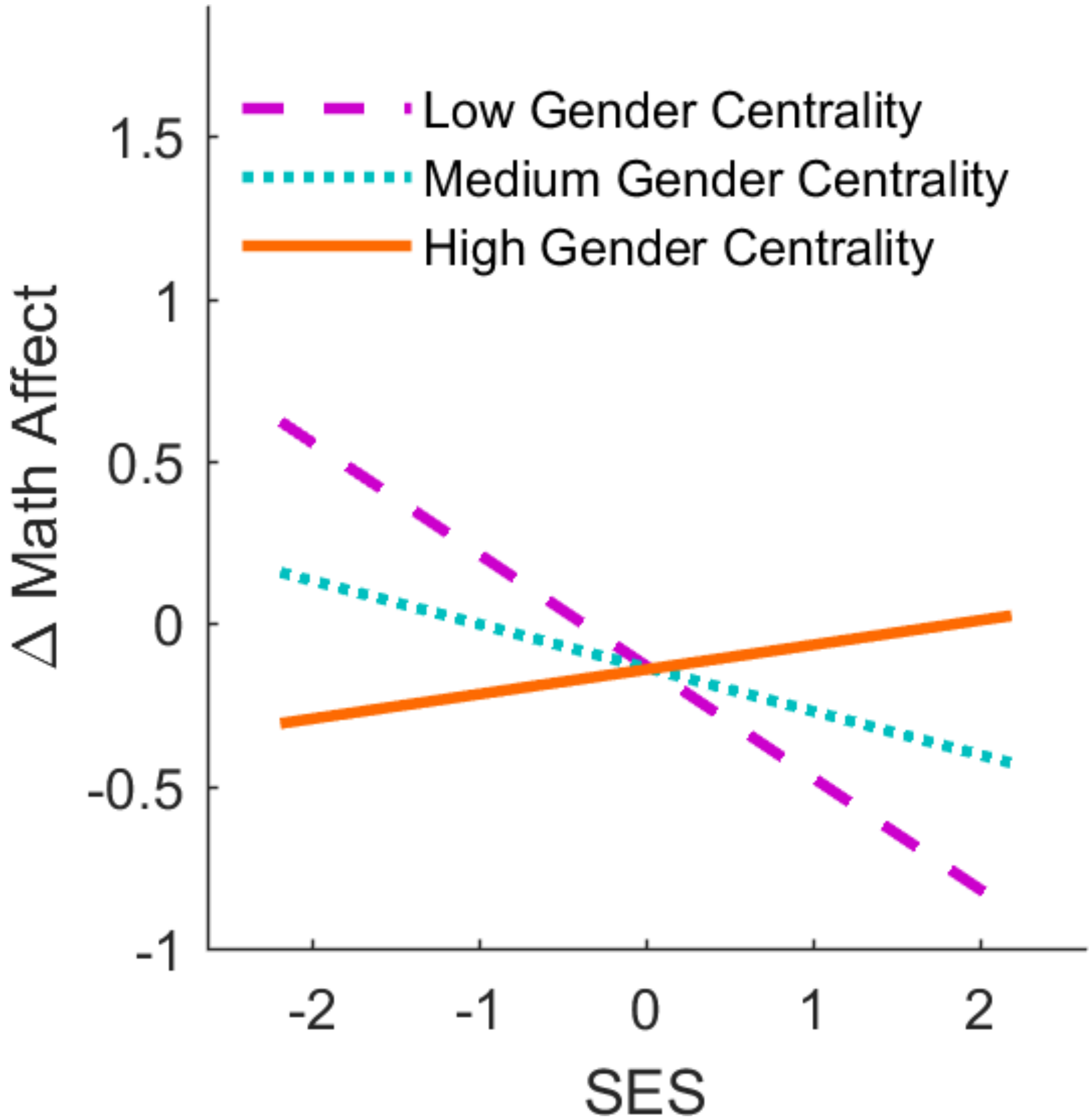

Figure 4. Math affect change as a function of gender centrality and SES.

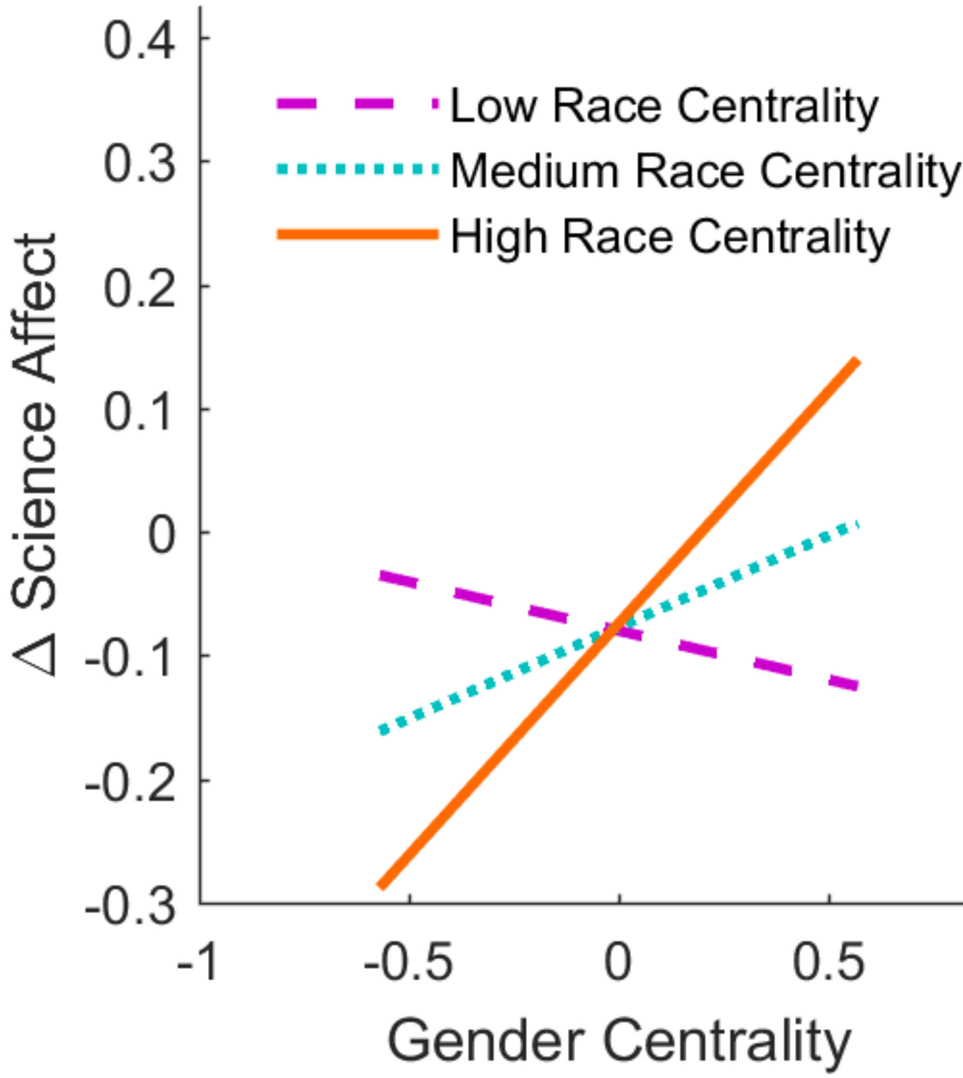

Figure 5. Science affect change as a function of gender centrality and race centrality.

Table 1.

Pearson Correlations

Variables	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1. SES	–											
2. Gender centrality	.067**	–										
3. Preparation for bias	.095**	.092**	–									
4. Race centrality	.081**	.230**	.136**	–								
5. Math affect (W3)	-.012	.108**	.106**	-.074**	–							
6. Math affect (W4)	-.024	.063**	.072**	.004	.495**	–						
7. Science affect (W3)	.122**	.155**	.133**	.011	.349**	.253**	–					
8. Science affect (W4)	.086**	.148**	.152**	-.017	.327**	.211**	.817**	–				
9. Math grade (W3)	-.180**	-.048*	-.055**	.039*	-.121**	-.086**	-.031	-.072**	–			

10. Math grade (W4)	-.026	-.061**	-.011	-.014	-0.032	-.122**	.009	-.025	.416**	–		
11. Science grade (W3)	-.234**	-.089**	-.032	.021**	-.210**	-.090**	-.179**	-.265**	.386**	.180**	–	
12. Science grade (W4)	-.133**	-.133**	.041*	-.078	-.085**	-.059**	-.113**	-.090**	.033	.039*	.208**	–

NOTE: $^{**}p < .01$ $^{*}p < .05$

Table 2.

Descriptive Statistics for key variables across SES

Variables	*M*	*SD*
SES	-	-
Gender centrality	3.41	.57
Preparation for bias	2.59	.99
Race centrality	3.51	.73
Math achievement change	-.13	.31
Science achievement change	-1.93	8.95
Math affect change	-.04	.73
Science affect change	-.04	.41

Table 3.

Descriptive Statistics for affect and achievement across SES groups by grade level

Variable	*M*	*SD*
Math Achievement 10th grade	1.29	.24
Math Achievement 12th grade	1.14	.29
Science Achievement 10th grade	1.11	.31
Science Achievement 12th grade	2.84	.60
Math Affect 10th grade	-.01	.60
Math Affect 12th grade	-.03	.74
Science Affect 10th grade	-.03	.65
Science Affect 12th grade	-.04	.82

Table 4.

Descriptive Statistics for key variables by SES

Variable	**Low SES**		**Medium SES**		**High SES**	
	M	*SD*	*M*	*SD*	*M*	*SD*
Gender centrality	3.27	.60	3.42	.58	3.51	7.44
Preparation for bias	2.39	.92	2.61	.92	2.73	.56
Race centrality	3.31	.81	3.57	.73	3.63	.57
Math achievement change	-.20	.27	-.17	.31	-.07	.08
Science achievement change	-1.20	12.55	-2.26	7.93	-.02	8.41
Math affect change	-.06	.87	-.01	.73	-.07	.62
Science affect change	-.01	.36	-.04	.46	-.09	.31

NOTE: Low SES = 1 SD below the mean, Medium SES = at the mean, High SES = 1 SD above the mean

Table 5.

Descriptive Statistics for affect and achievement by SES and grade level

Variable	**Low SES**		**Medium SES**		**High SES**	
	M	*SD*	*M*	*SD*	*M*	*SD*
Math Achievement 10th grade	1.35	.19	1.27	.27	1.20	.21
Math Achievement 12th grade	1.18	.29	1.12	.33	1.13	.30
Science Achievement 10th grade	1.26	.20	1.13	.31	1.07	.30
Science Achievement 12th grade	1.89	.08	1.90	.07	2.58	.03
Math Affect 10th grade	.02	.57	.07	.63	.06	.54
Math Affect 12th grade	.14	.72	.02	.74	-.02	.73
Science Affect 10th grade	-.14	.52	.01	.72	.14	.57
Science Affect 12th grade	-.12	.81	-.03	.86	.15	.72

NOTE: Low SES = 1 SD below the mean, Medium SES = at the mean, High SES = 1 SD above the mean

Table 6.

Regression Analyses for variables predicting changes in Math/Science Achievement and Affect

	Math Affect Change			Math Achievement Change			Science Affect Change			Science Achievement Change		
	β	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*	*β*	*SE*	*p*
SES	-.13	.12	.280	.28	.12	.023	-.04	.10	.705	-.15	.15	.314
Gender Centrality	-.01	.15	.944	-.11	.15	.473	.15	.11	.196	-.01	.24	.954
Race Centrality	.07	.144	.628	-.02	.15	.905	.01	.11	.974	-.35	.14	.015
Preparation for Bias	.06	.14	.67	-.02	.14	.873	-.02	.11	.876	.16	.13	.233
Gender Centrality x Race Centrality	.27	.18	.13	-.32	.16	.045	.31	.12	.010	.36	.24	.127
Gender Centrality x Preparation for Bias	-.03	.16	.829	.08	.17	.673	.04	.11	.732	.13	.19	.496
Gender Centrality x SES	.37	.18	.038	-.36	.15	.016	-.08	.13	.528	.16	.29	.587
Preparation for Bias x Race Centrality	.02	.14	.879	.01	.16	.983	.02	.11	.835	.05	.17	.752

Race Centrality x SES	-.02	.18	.907	-.07	.18	.687	.12	.13	.328	-.49	.25	.053
Preparation for Bias x SES	-.11	.15	.437	.06	.14	.691	-.10	.12	.324	.44	.18	.016

Appendices

Appendix A: Measures

Gender Centrality

Items	Values
Being female/male has little to do with how I think about myself	1= Strongly disagree 2= Disagree 3= Neutral 4= Agree 5= Strongly agree
I prefer to watch movies or television programs that have been made to appeal to girls and women/boys and men	
Being female/male is an important part of my self-image.	
Being female/male has a lot to do with how I think about myself	
Being female/male is unimportant to my sense of who I am	
I prefer to read books that are mostly read by girls and women/boys and men	

Racial Centrality

Items	Values
Being Black is an important part of who I am.	1= Strongly disagree 2= Disagree
I have a strong sense of belonging with Black people.	3= Neutral 4= Agree
I prefer to watch movies or television programs in which Black people are the main characters.	5= Strongly agree
I feel close to other Black people.	
Most of my friends are Black.	
I prefer to read books in which Black people are the main characters.	

Racial Socialization - Preparation for Bias

Items	Values
T3: Talked to you about racism.	1= Never 2= Once or twice 3= 3 to 5 times 4= 6 to 10 times 5= More than 10 times
T3: Said that people might treat you badly due to race.	
T3: Talked about something you saw on TV that showed poor treatment of Blacks.	
T3: Said that people might try to limit you because of race.	
T3: Talked to you about a different view of things you learned in school.	
T3: Told you that Black kids must be better than White kids to get the same rewards.	

Math/Science Interests and Expectations

Items	Values
How interested are you in the material you learn in your Math class? How interested are you in the material you learn in your Science class?	1= Not at all interested 2= Not very interested 3= Neutral 4= Sort of interested 5= Very interested
*In the future, how likely are you to enroll in an Honors or Advanced Placement class in Math? *In the future, how likely are you to enroll in an Honors or Advanced Placement class in Science? How likely are you to pursue a career in Math? How likely are you to pursue a career in Science?	1= Not at all likely 2= Not very likely 3= Neutral 4= Sort of likely 5= Very likely

*Not asked in wave 4

Math/Science Classroom Engagement

Items	Values
I work hard when we start something new in math [science].	1= Not at all true 2= Not very true 3= Sort of true 4= Very true
The first time my teacher talks about a new topic in math [science] I listen carefully.	
If a math [science] problem is really hard, I keep working on it.	
When I do badly on a math [science] test, I work harder next time.	
When I come to a math [science] problem that I can't solve away, I just give up.	

Math/Science Perceived Competence

Items	Values
Self-concept math	Range 1-25 1= Lowest 25= Highest
Self-concept science	

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