Statistical Models of Identity and Self-Efficacy in Mathematics on a National Sample of Black Adolescents from HSLS:09

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ABSTRACT

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The research reported in this study examined statistical relations in black adolescents' identity and self-efficacy beliefs in mathematics. Data for this research study were drawn from the High School Longitudinal Study of 2009 (HSLS:09; Ingels, Dalton, Holder, Lauff, & Burns, 2011) and the study's first follow-up (Ingels & Dalton, 2013); additional measures were taken from the National Center for Education Statistics' Common Core of Data (CCD). Data were analyzed using quantitative methods on a nationally representative sample of secondary school students (N = 1,362) across 944 schools in the United States. Although there has been an increase in *qualitative* research on mathematics identity and mathematics identity development, few researchers have utilized *quantitative* methods to empirically examine the relationships existing between identity and self-efficacy. Fewer researchers have used panel (longitudinal) data in their investigations. Findings from this study confirmed the literature in that mathematics identity development pathways are informed by students' mathematics self-efficacy beliefs. Sex differences were also noted. Specifically, males and females experienced divergence in their mathematics identity and mathematics self-efficacy beliefs during high school; however, the returns of these beliefs on a measure of Algebraic proficiency for females were significantly greater than they were for males, although females maintained less positive beliefs over the course of the study. School belonging and engagement significantly predicted shifts in students' mathematics identity development

pathways and were moderated by self-efficacy beliefs, supporting theories that measures of perceived differentiation (e.g., belongingness) are key factors in student motivation and subsequent outcomes. Additional findings underscored the ongoing need for empirical research on students' peer networks and mathematics teacher's classroom practices. Overall, results of this study indicated that variations in identity development and self-efficacy beliefs among adolescents extend beyond many theoretical considerations in both their complexity and measured effects when accounting for a host of contextual and psychosocial factors.

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LIST OF ABBREVIATIONS AND ACRONYMS

AGFI = Adjusted goodness of fit index

AIC = Akaike information criterion

BIC = Bayesian information criterion

CFA = Confirmatory factor analysis

CFI = Comparative fit index

HSLS = High school longitudinal study

IEM = Internal effects model

IREM = Internal reciprocal effects model

LVSM = Latent variable structural modeling

MSE = Mathematics self-efficacy

MID = Mathematics identity

REM = Reciprocal effects model

RMSEA = Root mean square error of approximation

SEM = Structural equation modeling

SRMR = Standardized root mean squared residual

SUR = Seemingly unrelated regression

W1STUDENT = HSLS student analytic weight (wave 1)

W2W1STU = HSLS student analytic weight (wave 2)

WLSMV = Weighted least squares means and variances

WMW = Wilcox-Mann Whitney

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DEDICATION

To my mother, Sharon—

you bring me joy.

PREFACE

"*Sticks and stones may break my bones but words will never hurt me*" is a well-known saying from many of our childhoods. Unfortunately, however, in research *words* have an impact on a wide array of opportunities—or lack thereof—made available to various communities. This dissertation was prepared as an addition to existing conversation surrounding the role of discourses and rhetoric.

*"*What is the value of knowing the income disparities or differences in crime and incarceration rates, differences in test scores, infant mortality rates, abortion frequencies or choices of sexual partner between different racial groups? How does the availability of this information shape public discourse, alter scientific research agendas, inform political decision making and ultimately influence the very social meaning of racial difference?*"*

― Tukufu Zuberi, *Thicker than Blood: Why Racial Statistics Lie*

*"*Please try to remember that what they believe, as well as what they do and cause you to endure does not testify to your inferiority but to their inhumanity.*"*

― James Baldwin, *The Fire Next Time*

*"*I had spent many years pursuing excellence, because that is what classical music is all about. Now it was dedicated to freedom, and that was far more important.*"*

― Nina Simone

Ubuntu.

CHAPTER ONE

INTRODUCTION

1.1 NEED FOR THE STUDY

More quantitative research studies are needed that critically engage perspectives on learning and teaching with regard to race and the function of social and psychological factors in the school environment. It has become common knowledge that differences exist across social constructions of racial groups and these inequalities have been long documented in the literature. From an historical perspective, differences in educational opportunities, experiences and outcomes across various groups of students have been examined and related to a myriad of political, economic, social and psychological factors (Anderson, 1988; Kozol, 1991; Oakes, 2005; Walker, 2005). There is an extant growing body of research focused at the intersection of particularly salient issues faced largely by African Americans in contemporary educational settings, issues that are either on par with or a mirror to what has been noted throughout American history (Anderson, 1988; Fairclough, 2007). Many of the issues detailed in earlier research on African Americans continue to persist. However, little has changed in the research approaches and frameworks utilized to understand these now common problems.

The representation of these persistent and enduring issues that are core to many research programs continue to contribute to longstanding social stereotypes. These stereotypes are at times based on supposed racial and cultural deficits or differences associated with blacks[1] in the United States and abroad. The majority of available research findings on the achievement of African American students focuses primarily on differences situated in race-based comparative frameworks—most notably the "achievement gap" (Carey, 2014; Gutiérrez, 2008, 2013; Ladson-Billings, 2006). As a result, many African American youth are positioned in the literature and policy research as underperforming, uneducable or in need of interventions without a sufficient regard for systemic, e.g., historical, sociocultural or sociopolitical perspectives—although these contexts are thoroughly examined in the literature.

However, in the majority of quantitative research, such implications are often presented using monolithic conceptions of race that interfere with both interpretation and ideological perspectives of the quantification practices (Zuberi, 2000; Zuberi & Bonilla-Silva, 2008). Researchers confronting these issues and presenting static perspectives of this sort also stereotype other seemingly higher performing groups such as Asian Americans through, for example, the "model minority stereotype" (Chou & Feagin, 2008; Lee, 1994, 2009; Hartlep, 2013). As a result, the quantification of race, especially with regard to outcomes in mathematics, has remained a mere descriptor variable instead of a multilayered construct (Martin, 2009a, 2009b; Zuberi, 2000). As such, this study sough to provide a more dimensioned view of black youth in the subject area of mathematics—arguably the heart of "achievement gap" debates—by engaging theorized hypotheses and empirical qualitative research using quantitative methods.

The lenses undertaken in many early studies generated an extensive body of findings that informed education policy seeking to both explain and identify factors

[1] Although the terms African American and black are used interchangeably in this study, the author urges the reader to consider perspectives on the social and political developments of race (see, for example, Omi & Winant, 1994; Leonardo, 2009; Martin, 2009b; Zuberi, 2000).

contributing to differential achievement outcomes between students. The Hauser Report (Hauser et al., 1964) and Coleman Report (Coleman et al., 1966) are two early examples, both of which make use of the term "achievement gap," that describe differences in academic achievement outcomes between blacks and whites. For example, the Coleman Report (1966) is described by it's authors as "the product of an extensive survey requested by the Civil Rights Act of 1964 survey [which] documents the availability of equal educational opportunities in the public schools for minority group Negroes, Puerto Ricans, Mexican-Americans, Oriental-Americans, and American Indians, as compared with opportunities for majority group Whites" (para. 1). During the twenty-year period in which these documents were published—the 1950s through 1970s—the government's focus on academic achievement and college enrollment through expanded educational opportunities shifted for a variety of reasons: one reason can be attributed to the effects of Sputnik (1957)—the world's first artificial satellite—which ultimately prompted the "Space Race" and was a part of the Cold War; and, a few years earlier, the *Brown vs. Board of Education of Topeka (1954)* Supreme Court case established that separate schools for black and white students was unconstitutional.

Specifically in the field of mathematics education, the aforementioned elements have been previously referenced as the start of a *New Math Era* (Kilpatrick, 1997). Debates and discussions of school mathematics induced education policy decisions based on ensuring America's competitiveness—which theoretically extends the so-called "achievement gap" to an international level and makes more visible the market-oriented goals of such rhetoric (Martin, 2013). These contexts have contributed to the continuation of a system that restructures itself based on debilitating perspectives of inequality and for national competitiveness. They also seem to have influenced public opinion with regard to the role of schools and equity as a stated priority in American public education policy (Kilpatrick, 1997). Later—around the 1990s— the *National Council of Teachers of Mathematics'* Curriculum and Evaluation Standards (NCTM, 1989) would prompt the "math wars" (Schoenfeld, 2004). Together these events caused a major spike in U.S. governmental programs focused on the elementary and secondary education pipeline, which paralleled increases in the focus on Science, Technology, Engineering, and Mathematics (STEM) education.

Some earlier policy contributions in STEM explored factors related primarily to the role of schools and classrooms, while others relied heavily on psychosocial constructs, and others on the sociological contexts. Over time, however, epistemological considerations in these areas of interest have remained imbalanced in both use in policy decisions and overall in the research literature, most notably with regard to race in quantitative studies of achievement outcomes. The quantification of race as a means to inform policy has relied heavily on comparative methodologies, which have now become the gold standard for large-scale policy research (Gutiérrez, 2008; Zuberi, 2000). The present study provided an exploration into many of the aforementioned aspects related to youth developmental outcomes but sough to challenge dominant narratives in the quantification process. In doing so, this study also sought to circumvent the political nature of race-based comparisons, e.g., "achievement gap" or racial differences, by thoroughly exploring variations *within* a nationally representative sample of black adolescents. This study made use of large-scale data to dispel monolithic rhetoric regarding blacks in mathematics. Instead, I present a narrative based in racial heterogeneity (Celious & Oyserman, 2001; Harper & Nichols, 2008).

Adolescent development has been a hallmark of theoretical and empirical consideration for some time (Erikson, 1950, 1968; Kroger, 2007). Using these frameworks, researchers have focused on different components of the *self* across various contexts. The growing body of literature on identity and the negotiation of identity in and across contexts has allowed researchers to understand students' ways of being as it connects their learning and *thinking* across marked developmental stages (Erikson, 1968). However, a synthesis of similar work has yet to be conducted in the quantitative domain. While current syntheses have been qualitative (Berry & Thunder, 2012), the body of research has notably provided a solid foundation upon which to confirm and explore the interrelations between identity and self-efficacy-related constructs and their correlates using quantitative methods. Moreover, there is an ongoing need for quantitative analyses that integrate critical frames of reference—most immediately to inform contemporary education policy.

1.2 PURPOSE OF THE STUDY

This study had three main purposes. First, I sought to understand and test theorized relationships between identity constructs and self-efficacy beliefs in mathematics based on the complex interactions presented in the literature. The majority of research in this area captures a measure of student beliefs during a single period and rarely accounts for a variety of social and psychological contexts that help to inform adolescent identity development (Berry & Thunder, 2012). In contrast, theoretical contributions seek largely to explain the temporal nature of identity and identity development processes; these theoretical perspectives have yet to become standard in empirical research studies where such methods and data are increasingly available. This dearth of quantitative literature can also be explained due to researchers' epistemological perspectives related to validating "facts" versus opinion; e.g., quantitative versus qualitative, "sociological" methods versus "psychological" methods, and/or critical versus non-critical approaches.

A second purpose of this study was to understand the varying effect sizes of the identified social and psychological factors on a measure of students' Algebraic proficiency. The factors outlined in the research hypotheses (see Chapter two) have been shown to have significant effects on student beliefs and their learning outcomes but—most importantly—they are rarely examined altogether in a single research study. Quantitative analyses and structural equation modeling methods used in this study provided the means to confirm well-theorized constructs. It should be noted that achievement and/or proficiency outcomes are not necessary in an investigation of identity and self-efficacy developmental processes; however, they do help generate a different substantive discussion when such processes are situated in school contexts.

Third, I wanted to understand if sex differences existed in returns on the aforementioned measure of Algebraic proficiency as it related to shifts in students' mathematics identity and self-efficacy beliefs. I also wished to understand the relationships existing between males' and females' beliefs over the course of their high school careers. While examining sex differences could also result in static interpretations as well, understanding these differences with care has helped others to prompt empirical research focused on an additional salient feature of adolescent identity development—gender. Thus, the research questions for the study are:

1) *What factors contribute to variation in students' mathematics identity, self-efficacy and Algebraic proficiency in secondary school contexts?*

2) *How are students' mathematics identities and self-efficacy beliefs in related and moderated within and across the secondary grades?*

1.3 PROCEDURES OF THE STUDY

A nationally representative longitudinal data set was used to answer the research questions and to test the hypotheses for this study. Information on students' mathematical backgrounds, attitudes, and beliefs were used, in addition to data on a measure of their Algebraic proficiency. The High School Longitudinal Study of 2009 (HSLS:09) (Ingels, et al, 2011; Ingels & Dalton, 2013) met each of these needs for the current study. The first wave of HSLS:09, conducted during the 2009–2010 academic year, included 944 schools. The study was designed to provide representative data for high school students, parents, teachers, and counselors across the United States. The original wave 1 cohort included 21,444 secondary school students from public, private, charter, and Catholic schools. The procedures used to answer the research questions for this dissertation study were employed on a subsample of black HSLS:09 students. I generated a final study sample using variables to account for the interdisciplinary focus of the study. The HSLS:09 sampling weight, w2s1stu, was utilized to generate a well-defined and nationally representative sample of black students. The final participant sample for this study included 1,362 black youth.

This study's analyses were conducted using quantitative methods in the family of Structural Equation Models (SEM) (Kline, 2010); additional statistical analyses were conducted based on the hypotheses presented in the second chapter. Given the nature of the data set and associated variables for the study, I used latent variable structural equation modeling (LVSEM). The LVSEM framework encompasses statistical methods such as basic and advanced regression analyses. It also includes methods that measure the development of factors to analyze latent constructs. These constructs allow researchers to examine statistical associations between multiple variables simultaneously (Kline, 2010). In contrast with other statistical methods, SEM models allow researchers to investigate sound theoretical frameworks using well-grounded empirical measures as a means to confirm assumptions and previous findings (Kline, 2010). Given the interdisciplinary nature of the current study, LVSEM provided the tools necessary to measure intersecting fields of thought based on some common theoretical assumptions with regard to mathematics identity development. SEM was used for more methodologically sound reasons as well; these reasons are outlined in the third chapter.

1.4 ORGANIZATION OF THE STUDY

In the next chapter, I provide a review of relevant literature related to the research questions outlined and the theoretical assumptions presented. It begins with an explanation of various perspectives on race and identity in mathematics education. This chapter ends with a detailed outline of the research hypotheses. Chapter three details the methodological and analytical techniques employed to accomplish the research goals outlined throughout the study. Chapter four presents a comprehensive analysis of findings based on the techniques outlined in chapter three. Chapter five then summarizes the findings and concludes by identifying potential questions for future research studies, focused specifically on strategies for understanding the complex relationships present in identity development processes. This study also contains tables and figures that are presented within the text of the document and in an appendix; all cited references are provided for the reader at the end of the document.

1.5 DEFINITION OF KEY TERMS

The key terms below are provided based on their use in the present study.

Cronbach's Alpha: *A psychometric coefficient of internal consistency among a set of parameters or items.*

Endogenous variable: *Endogenous variables (similar to dependent variables) are predicted by at least one other variable in a given model.*

Exogenous variable: *Exogenous variables (similar to independent variables) are not predicted by any other variables in a given model.*

Item Response Theory (IRT): *A method for the design and relational scoring of tests or questionnaires measuring ability or attitudes.*

Latent Variable: *A statistical model that sets a relationship between a set of manifest variables to infer an unobservable characteristic or set of characteristics.*

Manifest Variable: *A variable that can be directly measured or observed.*

Observed variable: *Observed (measured) variables are real values in the data set.*

Seemingly Unrelated Regression (SUR): *A set of statistical equations that have a cross-equation correlation between their error terms.*

CHAPTER TWO

REVIEW OF THE LITERATURE

In this chapter I provide a review of theoretical perspectives and empirical research studies that are related to the variables analyzed in the study. This chapter is divided into five sections. The first section discusses research on race and mathematics education in the United States. The purpose of this section is to help the reader understand the connections made in the previous chapter regarding the function of race in mathematics teaching and learning contexts and in education more generally. The second section provides an analysis of identity and identity development processes in education. The literature in this section was pulled from various research fields and focuses on those conceptions from different fields that provided notable points of entry for statistical analyses. The third section defines and considers perspectives on self-efficacy theory and theorized relations to the concept of identity formation. The following section—section four—provides an analysis of widely studied correlates of self-efficacy and identity in mathematics-specific contexts. In the fifth and final section, I describe and discuss the study's hypotheses; the research hypotheses describe the various facets of a framework I present, which was used in the statistical models analyzed.

2.1 RACE AND MATHEMATICS EDUCATION

The Education of Blacks in the South, *1860 - 1935*, James Anderson's (1988) detailed account of the education of blacks in the segregated south, provides various links connecting structured inequality at the institutional level to persistent inequities at more local levels for blacks in the United States. Researchers have contended that what

Anderson (1988) and others (see, for example, Asante, 1991; Fairclough, 2007; Walker, 2005; Woodson, 1933) identified contributes to understanding the differential learning opportunities and subsequent achievement outcomes impacting black Americans. These discussions have become more salient since the integration of public schools resulting from the *Brown vs. Board* Supreme Court Case. Since this period, a wide range of empirical research studies has contended with the ways in which these historical contexts affect students' perceptions of their skills and abilities.

Research on the construct and effects of race has noted that social and political perceptions of this construct have real consequences in the daily experiences and connected outcomes of individuals (Asante, 1991; Bonilla-Silva, 1997; DuBois, 1939; Lee, 1994, 2009; Omi & Winant, 1994). The causal effects of both history and interpersonal relations present themselves in institutions such as schools and in classrooms. Yet some earlier research on intelligence and culture (e.g., Herrnstein & Murray, 1994; Thernstrom & Thernstrom, 2003) positioned African Americans alongside deficit cultural frames as a means to explain differential achievement outcomes. These studies very carefully position their arguments without note of the structured systems of inequity that exist presently and those documented in both legal and research documents. As a result, an increasing amount of counter narratives (Solórzano & Yosso, 2002) on the schooling experiences of African Americans specifically has been needed to identify and help rectify inseparable perceptions between race and education in American society in the broader literature (Anderson, 1988). Far less of this foundational work has been done in quantitative studies (Zuberi, 2000).

This important connection between race in mathematics teaching and learning has been made by a host of scholars (Berry, 2005, 2008; Gutiérrez, 2002, 2008; Gutstein, 2003; Moody, 2000; Moses & Cobb, 2001; Nasir, 2002, 2005; Stiff, 1990; Stinson, 2006, 2008; Tate, 1995). As noted earlier, it has been well documented in mathematics education research literature that race is one of the most salient characteristics for differential treatment in the discourse that surrounds the “achievement gap” (Diversity in Mathematics Education (DiME), 2007). In line with such arguments, researchers have discussed the damaging effects of "gap gazing" and a level of critical thought that is needed when examining racial differences in achievement outcomes (Gutiérrez, 2008). Others have introduced terms such as the "opportunity gap" (Flores, 2007) to help explain racial differences in academic performance. The variations in opportunity structures and the effects these differences have on students’ outcomes is a key component of understanding inputs and associated outputs. The gap as described by Flores (2007) helps to shift blame away from the individual and on to larger, macro-level issues based on structural and institutional differences that impact opportunity. However, more research is needed with regard to understanding the effects of such processes at an individual level and an understanding of trends that exist across groups.

Martin (2000, 2009b, 2013) has made a strong case about the salience of race in mathematics education. He has also noted the effects of research on the achievement gap and other "market projects" upon which the status quo consistently marginalizes students of color (Martin, 2013). Martin contends that African American youth “do not come to mathematical contexts as blank slates, free of their experiences as African Americans” (Martin, 2007, p. 148). As such, researchers have come to understand that learning mathematics is indeed a racialized process in light of the many messages that are sent about who can and who cannot do mathematics (Martin, 2007). Also important in these discussions is the fact that youth are not only aware of these messages and stereotypes but they go on to inform their subsequent behaviors (Shah, 2013).

As a result, research on black youth must extend beyond “achievement gaps” and differential outcomes and focus on inputs and systemic structures that inform differences commonly noted in mathematics education research (Asante, 1991; Flores, 2007; Gutiérrez, 2008; Gutstein, 2009). Moses & Cobb (2001) took an historical approach and identified a host of issues present by noting the link between the historical infringements on African Americans’ civil rights with regard to literacy and voting, especially in the southern states. This research on mathematics teaching and social justice (e.g., Gutstein, 2006; Gutstein & Peterson, 2013) has also linked the larger structural systems of inequity to pedagogical matters. These conversations note the tradition and importance of giving students the knowledge and power to understand and change dominant narratives and realities. At the center of each of these arguments is the formation of a strong mathematics identity.

These identities generally support human capacity to better navigate dominant structures, as well as hold strong beliefs in their own individual ability to produce context specific outcomes, or their self-efficacy beliefs. Self-efficacy is in many ways more centrally focused on beliefs regarding content intake and cognitive capacities related to mathematics knowledge in standard school settings. Boykin & Noguera (2011) examined various guiding functions of social and cognitive theories as they relate to various issues of equity; they construct a detailed picture of self-efficacy. The authors note that “as the learner approaches a given task, he or she is implicitly or explicitly involve in a self-questioning process: 'Can I do this task in this situation?' The pattern of his or her actions will be different, depending on the answer" (Boykin & Noguera, 2011, p. 52). The *guiding functions* provided by Boykin & Noguera position a cluster of factors that have repeatedly been shown to relate to various processes of engagement and outcomes, related to one's identity. Connectedly, as noted by Spencer & Markstrom-Adams (1990): "[when studying] identity as a broad construct, it is possible to relate identity to other components of the self system…[which] includes dimensions of self development and self-perceptions, such as self-recognition, self-awareness, self-esteem, and locus of control" (p. 291). The next section of this study seeks to explore various conceptions of identity and the *self*-systems presented in the literature, especially those related to black adolescents in an U.S. context.

2.2 IDENTITY AND MATHEMATICS IDENTITY

Identity and Identity Development

There exist multiple perspectives that have contributed to theories on the *self* and human developmental processes at the adolescent level. With regard to identity, there appears to be a variety of overarching philosophical perspectives that have been used in the literature with regard to identity development along the human life cycle. In education, specifically, these perspectives have been utilized in studies as a means to further detail the processes under which youth come to understand themselves based on a host of factors that are external to their cognitive processes but ultimately affect the ways in which these processes are carried out. The psychological perspectives focus primarily on the individual and internal cognitive processes (Bandura, 2001). In this study, these theorized processes have been integrated across fields that consider the foregrounding sociocultural and social ecological perspectives as a means to define or explain *sociopolitical* content. While these fields clearly overlap, their interrelation is three-tiered: the sociocultural perspectives tend to focus on interactions between the individual and their contexts, these beliefs are developed in the ecosystem; research and policy focus heavily on discourses, which provide the connection to the sociopolitical domain.

Identity formation is a constant process of finding oneself or of *becoming*. For this study, I attempted to find a nexus between these divergent and convergent perspectives to study the interrelated characteristics of mathematics identity development processes—which, in essence, are stochastic processes and randomly determined—alongside a concept of mathematics self-efficacy and related correlates. Namely, I presumed that the identity development process in mathematics education involves the practice of *becoming*. This process includes individuals interacting within historically developed norms and social conditions that require the exercise of various mechanisms—or guiding functions (Boykin & Noguera, 2011). When such norms are maintained and some are disrupted cognitive processes as a result of these various coping mechanism play into the development of new identities. The developmental process in learning mathematics is a complex cognitive and social process that varies in relation for each individual. These processes are informed by various self-beliefs that help to structure subsequent beliefs and become foundational markers to the central components of an achieved identity. Exploring variation of these processes within group was an overarching goal in this study.

From a broader view, human developmental theories have generally pointed to multiple developmental stages throughout the life course that further complicate the aforementioned processes (Erikson, 1950, 1968; Marcia, 1960). Theories have identified the development and negotiation of various identities and identity development processes as they relate to adolescent decisions making (Erikson, 1950; Kroger, 2007; Wenger, 1998). Moreover, research on identity development processes have incorporated external forces grounded in social experiences and interactions beyond mere linear relations, while others have been focused on internal factors germane to psychological processes that rely more heavily on non-linearity.

Eriksonian theories (Erikson, 1950, 1968) of identity development posit that we experience an identity crisis that is most pronounced, and never fully resolved, during the adolescent years. In this crisis, Erikson states that humans undergo the task of establishing a personal identity and can face "role diffusion" and "identity confusion," that could lead to self-destructive behaviors or opposing positive outcomes. In Erikson's theories, avoiding these self-destructive behaviors and the role or identity confusion requires that adolescents develop a meaningful self-conception that brings together their past and present experiences, and utilizes contributions to students' future conceptions of themselves. Erikson (1968) posits that the human development cycle is riddled with "conflicts, inner and outer, which the vital personality weathers, reemerging from each crisis with an increased sense of inner unity, with an increase of good judgment, and an increase in the capacity 'to do well' according to his own standards and to the standards of those who are significant to him" (p. 91-92).

Marcia (1960), who built on Erikson's theory, generated an *Identity Status Theory*. His theory hypothesized that identity development consists of four non-hierarchical phases. These phases are: identity-diffused, foreclosure, moratorium, and identity-achieved. In Marcia's theory, identity-diffused youth have not yet had the adolescent identity crisis or explored various role or beliefs attached to these roles. The foreclosure phase is the commitment to certain goals, values, or beliefs without a significant identity crisis. In this stage, socialization by parents and others significantly contributed to the development of an identity rather than exploration or experiences. The moratorium stage is a stage of exploration in which an adolescent may take on many different roles and values in search of a well-suited identity. The identity-achieved stage is one in which an identity has been achieved and a personal commitment to the set of beliefs and values that go along with this identity are accepted. These identities may remain stable or shift due to varying circumstances, which, as a result, make the study of more context-specific beliefs—such as self-efficacy beliefs—central to understanding the identity developmental process in mathematics.

Elsewhere, Gee's (1999) conceptions of identity, which have been previously utilized by researchers in science and mathematics education, positions perspectives focused on individual agency in identity development. This agency is in contrast to what is generally presented by Erikson (1950) and Marcia (1960). Specifically, Gee defined identity as "the kind of person one is seeking to be and enact in the here and now" (1999, p. 13). This concept of identity engages the fact that identity is a self-regulated response process where one seeks or adheres to an identity based on the presented forms of participation and perceptions held by others (Carlone & Johnson, 2007; Gee, 1999, 2000;

Wenger, 1998). One example in the science education literature using Gee's definition is provided by Carlone & Johnson (2007).

Carlone & Johnson (2007) conceptualized science identity based on three interrelated dimensions: competence, performance, and recognition. This three-pronged framework from a socially constructed perspective provided the authors with the opportunity to understand identity in overlapping and shifting contexts based on the individual experience. In their study, they found that competence was necessary for identity development but did not predict the type of identity that one held. They also found that performance did not predict the type of identity that one would hold. It was recognition, the communal aspect, which proved to be the nuanced factor in their findings. The identity development process, as noted in Carlone & Johnson (2007), does not come packaged as one might expect. It involves the interrelations of self-beliefs and our perceptions of the beliefs from others. Identity formation, as noted by Spencer & Markstrom-Adams (1990), can consist of "conflicting values—those of the larger society and those of the reference group—from which he or she must choose in forming an identity" (p. 301). Thus, with both historical and relational views in mind, the developmental process for black youth—and other minority groups—is further nuanced based on larger stereotypes and societal narratives.

Gee (2000) also provided a more focused perspectives on identity as an analytic lens in education research. In addition to other research on identity, Gee's (2000) work helps to establish a broad-based view on changing identities within educational contexts. Later, Gee defined identity as one "being recognized as a certain 'kind of person,' in a given context…not connected to their 'internal states' but to their performances in society" (2000, p. 99). The lack of focus on internal states but instead on performance follows in line with the provided example but fails to account for variation in human developmental processes; namely, the significance of recognition or performances in society. Gee (2000) introduces the concept of the core identity, which is presumed to be more stable across multiple contexts. It is within Gee's core identity framework that I established a connection to more internalized states of being as presented by Bandura (1977, 1986, 2001) and others as a means to further explore identity development temporally. Gee's (2000) conception of identity using a sociocultural framework accounts in ways for current thinking about the role of individual beliefs in human action.

Lave and Wenger (1991) have also posited that learning is in itself an identity development process; more specifically, the authors describe it as a social process in which we come to know who we are. Lave and Wenger (1991) have situated learning as a process of identity formation based largely in various forms of participation. This concept accentuates the role of the ecological contexts on the individual. Within their framework, the identity development process is one in which students negotiate multiple versions of the *self* and place meaning on these various *selves*. In doing so, they underscore that individuals do not have one but, instead, many identities. From Lave & Wenger's (1991) perspective, identities are unstable and vary in the degree of power that represent the central developmental component in the process of learning. In addition to identities serving as pivot between the social and the individual, for researchers taking on this perspective, it also serves as dominant factor in the development of students' beliefs.

In this study, I sought to quantify how black secondary school students' "mathematical [identities] might be formed and developed-and evolve-over time," as prompted by Walker (2012, p. 69) in her discussion of Black mathematicians. A host of research studies have taken on sociocultural and psychological perspectives of identity. It has been widely noted that notions of identity with relation to learning and teaching do best by examining an identity of practice, "one that is constantly being formed and reformed in dialectic between social structures and individual lived experiences" (DiME, 2007, p. 409). Understanding trends in this reformation is an issue of temporality. These particular lenses became important to the current study in the positioning of students *within* schools, where reformation of beliefs and ideas happen as they would in the normal life course but now occur within a *seemingly* well-defined institutional space. I have conceptualized identity as a "pivot" between the social context and individual's beliefs (Wenger, 1998). In doing so, I make use of, for example, Bronfenbrenner's (1979) and Spencer's (1995) ecological systems theories to explore notions of resilience as it relates to self-efficacy during students' experiences in secondary school mathematics. Utilizing such frames in reviewing the literature allowed me to link contexts with individual perceptions. As a result, I was able to examine data for more theoretical structuring of identity focused on students' perceptions, while theoretically accounting for variation in the effects of systemic features and students' race-based identities.

Mathematical Identities and Mathematics Identity Development

Research on identity in mathematics education has most often been framed as how an individual thinks of himself or herself as a mathematics learner or doer (Boaler, 2002; Martin, 2007). In this study, mathematics identity was defined as an individual student's beliefs and centrally relates student perception of others' beliefs about their status as a mathematical person as well. Given the relationships defined, linking other factors with students' perceptions provided an entry point to examine how these factors can be effectively positioned in the literature from a more temporal lens. This definition of identity was also based on a synthesis of additional related literature

Boaler, Williams, & Brown (2000) examined identities among secondary mathematics students using a Communities of Practice (Lave & Wenger, 1991) framework. The authors examined the processes related to students' becoming in in-school classroom-based mathematical communities of practice. A majority of students in both settings of their study, the United States and the United Kingdom, viewed mathematics as a "procedural, rule-bound subject" that offered little flexibility and opportunity for them to insert individual components of themselves (Boaler et al, 2000, p. 6). They found, especially among students in the U.S., that unstable mathematical identities and a propensity toward disliking mathematics were often due to a sense of abstractness in the subject. Students from the United Kingdom reported less dislike for mathematics but did not have strong or stable mathematical identities. Although the classrooms presented in their study provided an "unambiguous vision of what it means to be successful at mathematics, and of what it means to be a mathematician," the researchers found that students struggled to identify with the concept of actually becoming a mathematician (Boaler et al, 2000, p. 6). Students most often wanted to study mathematics and be successful in the practice of mathematics in their current contexts. As Esmonde (2009) argued, the processes related to students' identity development are central to students' mathematics content acquisition in cooperative learning environments. This may help with positioning the identity development process in specific mathematical contexts over time that only allow for one to generate an understanding of mathematical identities in retrospect. In this line of thinking, understanding self-efficacy beliefs and the specificity of these beliefs is warranted.

The importance of understanding student beliefs in more specific contexts is further supported by the structured relationships discovered between identity, goals, and practice. Nasir's (2009) study on mathematics in cultural practice provides this extension. Studying African American students from two separate investigations of elementary and secondary school students in out-of-school contexts, Nasir (2009) found that individuals' practice-based goals and mathematics goals merged and shifted in the development of their identities. These shifts were from novice to more intermediate and then advanced level practices. She found that these identities were grounded in learners' engagement. Nasir also found that reciprocal relationships existed between identity, goals, and learning. Specifically, she found that learning is more than the process of becoming and the meaning attached to one's participation. As students develop various identities along a temporal trajectory from novice to expert, the meaning that they attached to their participation helped to mitigate the identity development process. Focusing more narrowly on the nature of beliefs that develop alongside students' identities help researchers better understand the process of becoming through the varied beliefs that students attach to their identities. Esmonde's (2009) positioning aligns with this connection as well. Notably, content acquisition is a practice in which students place meaning in multiple areas and it is through this process that their beliefs and identities are developed.

Martin (2006) defined mathematics identity as "the dispositions and deeply held beliefs that individuals develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics to change the conditions of their lives" (p. 8). In his research, Martin discusses mathematical socialization in the many contexts aligned with the previous research on mathematics identity presented. As a process of socialization, identity development for Martin includes what it means to do mathematics and students' beliefs about success or failure in doing mathematics. This definition of socialization provides a direct link to self-efficacy beliefs as students begin to structure their own skills in comparison to those of others through, for example, the model of triadic reciprocation presented by Bandura (2001) and the contexts upon which the expectations of *doing* mathematics are situated. Martin's conception, however, contends more directly with the relational aspects that are not commonly accounted for in primary psychosocial perspectives.

For example: a student may hold higher self-efficacy beliefs in Algebra I but may have been situated or socialized to be positioned as a person who is more likely to perceive of themselves as a failure in more advanced courses, like Calculus. In this example, mathematics identities can vary both within and across specific courses and contexts, which brings us back to the earlier points made with regard to different contexts linking to different beliefs (Gee, 1999, 2000; Lave & Wenger, 1991). Research scholars have investigated African American students' racial and mathematical identities as an example of a similar complex processes across contexts (Berry, Thunder, & McClain, 2011; English-Clark, 2011; English-Clarke, Slaughter-Defoe, & Martin, 2012; Martin, 2000, 2007; Spencer, 2009). While results from these studies have varied, these scholars have consistently found a variety of racialized experiences that permeate students' ways of thinking and becoming in different mathematical context—all of which had a significant impact on a host of student outcomes. In this view, the external factors play a major role in helping to moderate the ways in which students' identities are developed; especially if narratives are present that further reduce students' beliefs, belonging and engagement. It was assumed that all student participants in this study had undergone or experienced some form of racial identity development and that this development was in some way related to the development of their mathematics identity. While the focus on racial identity development was beyond the scope of this study, the literature discussing why and how these contexts are central to any study examining identity development processes for black adolescents.

Mathematics identity development among black youth was also conceptualized based on the perspectives provided by Spencer & Markstrom-Adams (1990) and Spencer et al (2003). In these reviews, a clarification between identity and other components of the self-system were provided. The authors, utilizing a variation of Bronfenbrenner's Ecological System Theory, noted that the "stereotypes that accompany minority-group status most often emanate from [a] macro level and are given structure and reality as they permeate the various levels of the ecosystem within which minority youth and their family must operate (e.g., microsystem)" (Spencer & Markstrom-Adams, 1990, p. 293). This framework helps to situate variants in students' identities and their attached beliefs. As larger systemic ideologies permeate more micro-levels of the ecological systems, students' beliefs become less fluid and nuanced during various identity development phases. These processes then require that we examine identity and identity development from both the sociological and psychological domains of knowledge (Côte & Schwartz, 2002).

2.3 SELF-EFFICACY AND MATHEMATICS SELF-EFFICACY

Self-efficacy

Social Cognitive Theory (SCT) is an extension of social learning theory. A basic premise of SCT is that people learn not only from their personal experiences but also by observing the actions of others and the cognitive processes that come as a result of those actions. SCT is an integration of behavioral and cognitive theories of learning and is situated as a component of larger identity development processes, which are discussed in the next section. A central component of SCT is reciprocal determinism, which posits that environment influences an individual's behavior and, in turn, their environments are influenced by individual behaviors (Bandura, 2001). Within these reciprocal exchanges are theories related to the development of the *self*, but from a focused psychological perspective. The locus of identity from this perspective is the individual and it relates to self-concept in more general settings and self-efficacy in more specific settings.

The work of Bandura (1989, 1997, 2001) sought to explain human behavior in specific terms of reciprocal determinism—a three-way, dynamic, reciprocal model—to incorporate individual factors, environmental factors and behavior in the context of the development of beliefs. In Bandura's (1989) definition, "social cognitive theory rejects the dichotomous conception of self as agent and self as object. Acting on the environment and acting on oneself entail shifting the perspective of the same agent rather than reifying different selves regulating each other or transforming the self from agent to object" (p. 1181). One main factor in SCT using Bandura's lens is that students' actions are influenced by the actions that they have observed in others. Observational learning in SCT underscores the importance of the integration of identity development processes but fails to account for the social and cultural processes within connected frames of reference. Spencer's (1995) PVEST framework focused on integrating critical social and cultural process into related domain.

Bandura's larger theory structures individuals' experiences while constructing differences between a global understanding of one's identity and more specific references to beliefs. It is important to differentiate the concept of identity from self-efficacy beliefs as self-efficacy beliefs relate to specific and often different tasks within the developmental processes (Boykin & Noguera, 2011). While motivation is rooted in other sources, such as goal setting and self-evaluative reactions, Bandura (1977) and others (Lippe, Wiedemann, Ziegelmann, Reuter, & Schwarzer, 2009; Pajares & Urdan, 2006) agree that self-efficacy and outcome expectations play a primary and critical role in human behavioral and developmental functions. Figure 1 provides a mapping of the social cognitive relationship between self-efficacy and learning expectations, such as Algebraic knowledge in a secondary setting, as presented generally in the research literature.

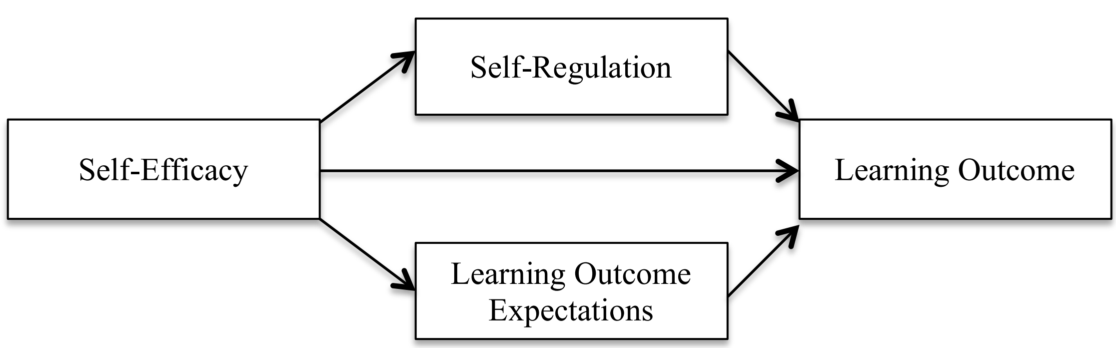


Figure 1. *Model of Self-efficacy and Learning Expectations*

Bandura (1977) noted that "expectations of personal efficacy are based on four major sources of information: performance accomplishments, vicarious experience, verbal persuasion, and physiological states" (p. 195). However, over the course of his tenure researching self-efficacy, these four sources have shifted slightly. Bandura ultimately identified these four sources as vicarious experiences, verbal persuasion, and psychological state, replacing performance accomplishments with enactive attainments. Experiences, or enactive attainments, are described as the most important factor in determining self-efficacy beliefs. Individual experiences, as described in Bandura (1986), point to the importance of judgment in building one's beliefs about their capabilities. In the utilization of enactive attainments, the focus of the judgments largely determines the subsequent beliefs and behaviors. Focusing on more positive and successful experiences of efficacy contributes to a more stable sense of self and the abilities attached to a particular activity. Contrastingly, focusing on more negative and less successful outcomes increases the potential that beliefs will initiate paths less related to positive outcome expectancies. In cases where past success is limited, these judgments become extremely crucial in the development of efficaciousness. While positive experiences are likely to produce a more positive sense of efficacy, they alone do not determine efficaciousness as much as where one chooses to focus their judgments.

Vicarious experiences are the modeling a person experiences from witnessing the behavior of others (Bandura, 1986). In light of individual experiences, vicarious experiences help a person determine and enact behaviors that likely lead to more successful, or desired, outcomes. These experiences have more traction when an individual is able to identify with the person, or persons, being observed. This further integrates the development of identity as relational and is integral to students' beliefs about their own self-efficacy. In line with more advanced mathematics learning, models of triadic reciprocity provide an opportunity for students to identify with the process of doing and approach the learning process from a more situated frame of reference in which *doing* become more process oriented and less identity dependent (Bandura, 1997).

Verbal persuasion is the sum of verbal cues that one receives from others. These stabilize individual's beliefs of ability to complete a particular task or inform belies with regard to whether or not one is competent in a particular set of skills (Bandura, 1986, 1997). Verbal persuasion has been found as an essential component to self-efficacy beliefs in the sense that verbal persuasion encompasses growth in a particular area or an ability to be successful at increasing one's proficiency in a particular area through interaction. These verbal supports are likely to maintain a sense of self that views seeming difficult situations as a goal to strive for and not a space or event to retract from, which is important in the study of more advanced mathematics (Boaler, 2013). In the school environment, verbal persuasions are most likely to come from teachers or peers. This does not, however, account for the value that individual's place on such persuasions (Dweck, 1999).

Psychological state is the perception of responses or one's ability to respond to various situations, especially those that present stress. Some examples of psychological states that have been more widely extended into the research on race can be noted in the research conducted on *Stereotype Threat* (Steele & Aaronson, 1995), *Stereotype Lift* (Walton & Cohen, 2003) and *Stereotype Management* (McGee & Martin, 2011). These research studies link specific psychological states to subsequent achievement outcomes for students in the process of developing mathematics identities. Psychological states are dependent on the ecosystem in which stressors are attached. The research conducted by Spencer (1995) and Spencer et al (1997) indicate how ecological contexts work in a reciprocal system with supports and stressors to help determine behavioral outcomes. This research pulls from the human development literature and further strengthens the links between self-efficacy beliefs and identity development.

Although the studies noted thus far have provided significant contributions to the way researchers theorize and investigate developmental processes, there are researchers who have differed in their beliefs about the internal processes on how human behaviors and actions are developed (Mickelson, 1990). Most of these differences were rooted in the origins of self-efficacy beliefs and the subsequent impact on human decision-making. For example, White (1959) used the term "effectance motive" to discuss human behaviors in response to their environment. White's theory of "effectance motive" relates the idea of novelty in environmental factors and individual knowledge. White specifically discusses what he feels produces novel stimulations to explain human behavior. White contended that as people function in their environment *new* knowledge about these environments and the identified skills attached to this knowledge to inform changes in behavior. However, Bandura (1977) noted that White's theory lacked specific details about how this motive "emerges from effective transactions with the environment" (p. 203). White's theory creates a cycle that informs itself which results in an inability to fully understand where human motives begin or end, or how they inform one another. This essential debate in human development is the primary reasons why empirical studies in this area have and continue to be conducted. Subsequent research utilizing these perspectives has contended with the complexity of the development process among diverse populations (Boykin & Noguera, 2011). In this study, identity and the identity development process only exemplify this cycle of reciprocity and the attachment to self-efficacy judgments. Further, self-efficacy judgments position beliefs across very specific contexts, like mathematics learning in a specific course or setting—both of which produce identities that interact and interfere with one another. Empirical studies related to this dynamic area of development provide opportunities to better understand these interrelations.

Bong (1999) studied the generality of academic self-efficacy judgments among 588 high school students. In the study, participants rated their confidence for solving 42 different problems in various subjects, one of which was Algebra. Bong found that students rated their strengths comparably as they perceived similarity between the types of problems being presented. The participants in Bong's study generalized their beliefs based on associations that they developed with problem types, the same way that beliefs can be generated based solely on perception and not experience. Pajares & Miller (1994) noted the importance of specificity when assessing student's' self-efficacy judgments while looking at mathematics self-efficacy and mathematics performance. In their study, beliefs become less dependent on perception but more focused on the context. Specificity matters in mathematics self-efficacy judgments. However, few studies have examined the self-efficacy beliefs of African American youth at this level of specificity (Jonson-Reid, Davis, Saunders, Williams, & Williams, 2005).

Uwah, McMahon, & Furlow (2008) examined the self-efficacy judgments of African American youth and their relation to a host of academic outcomes, such as school belonging. The judgments analyzed were not directly related to academic efficaciousness. The authors contend that academic efficaciousness is closely related but do not focus specifically on the ways in which beliefs help to inform larger, macro-versions of the *self*. Jonson et al (2005) contended that self-efficacy, rather than self-esteem, which has also been linked to identity development, serves as a more determinant factor for student success in school contexts, similar to Uwah et al (2008). In their study, Jonson et al's (2005) findings suggested that positioning education at the center of students' beliefs would help to increase their sense of efficacy in a variety of academic contexts.

Spencer, Cole, DuPree, Glymph, & Pierre (1993) examined a general measure of academic self-efficacy among African American adolescents and explored issues of risk, vulnerability, and resilience. In their study, the authors conceptualized self-efficacy as a coping mechanism and as an aspect of the identity development process. Using regression analyses, the authors found that academic self-esteem significantly predicted a measure of students' learning outcomes. One key finding was that among African American youth, cognitive performance was integral to students' success and resilience. As a psychological construct, self-efficacy and related measures of cognitive ability were important factors in understanding various situations that require the use of coping mechanisms, most notably a response to stress. Self-efficacy as presented in the literature requires a belief in ones capabilities to produce certain outcomes (Bandura, 1977). Higher levels of self-efficacy result in the likelihood that a student will be able to cope or deal with a difficult situation. As was the case with Spencer et al's (1993) conceptualization of self-efficacy as a coping mechanism, I employed and linked these two constructs similarly for African American youth. This connection was made based on the research literature focusing on more macro-level contexts where relevant and positive messages of being a "math person" are often far and few in between for black Americans (Martin, 2011; Walker, 2014). To hold both beliefs that allows one to consider themselves a mathematical person and also that others see them as a mathematical person requires a level of self-efficacy that is well supported by previous experiences of success—and ultimately should be correlated with a high or positive mathematics identity. Otherwise, various experience simply sum to inform a students' core disposition from static conceptions yet fail to account for the temporal nature of development as it is discussed in both sociological and psychological contexts.

Mathematics Self-efficacy

Bandura (1997) defined self-efficacy as the "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). For the purpose of the current study, mathematics self-efficacy was defined using the definition provided by Bandura (1997) but with a specific focus on students' self-beliefs in different mathematical contexts, supported by a measured relation between their identity dispositions, as noted by Spencer et al (1997). Self-efficacy was determined as being one of the factors primarily related to students' identity development, which focused on "being recognized as a certain kind of person" (Gee, 2000, p. 99). This connection was made due to the domain specificity that self-efficacy requires and also based on the shifting structure of students' beliefs throughout a variety of contexts. Relating the development of students' self-efficacy beliefs in more specific contexts to a general identity provides an opportunity to explore the factors' co-construction. Using a structural modeling framework, I was able to examine how these factors generally affected correlates and, additionally, how their shifts over time functioned for the sample population.

While modeling techniques allow researchers to connect a variety of theoretical perspectives in statistical tests for significance, other researchers have extrapolated these methods on a variety of samples using qualitative methods. Most of these studies focus on African American males and a need for more positive representations of males in the research literature (e.g., Berry, 2008; Berry, Thunder, & McClain, 2011; Thompson & Lewis, 2005). Thus, revisiting statistical models provides a base upon which to explore the continued significance of sex in outcome differences. These studies provided useful perspectives that help extend the need for the current study. One important inclusion in this review was studies that focused on sex differences in relation to student attitudes and beliefs in mathematics that utilized modeling techniques and/or similar measures.

In Randhawa, Beamer, & Lundberg's (1993) study, a structural model of mathematics achievement was tested with high school students (N = 225) and self-efficacy scales were used. Using a 2-group LISREL procedure to model mathematics self-efficacy as a mediator between mathematics attitudes and mathematics achievement, the authors found a good model fit for both males and females; there were also significant sex differences between two of the three path coefficients. A total of approximately 45% of variance in mathematics achievement was predicted from the model and mathematics self-efficacy had 41.6% variance in common with mathematics attitudes, generating near equal predictive values in the model. These findings exemplify the substantive information that can be gained from utilizing structural modeling techniques in a study on self-efficacy beliefs. However, while these studies of self-efficacy provide important information to how these beliefs functions overall, they seemed to follow in line with the majority of the hypothesized relationships in the literature utilizing predominately middle class white student samples. In the following paragraphs I specifically review research studies using black study samples.

Noble (2011) studied African American males' mathematics self-efficacy and found enactive attainments and vicarious experiences as influential forces in the development of positive self-efficacy beliefs. Noble found that the development of these beliefs were supported largely by a host of kinships—similar to those described by Walker (2014)—such as parent, peer, and family networks. Noble found that vicarious experiences, as opposed to enactive attainments as theorized by Bandura (1997) appeared to be more influential to the participants' self-efficacy beliefs. As one of few studies focused on self-efficacy beliefs among African Americans in mathematics, Noble's (2011) research provides a perspective to support exploring if the structure of the sources of self-efficacy is seemingly different for African American youth and/or minority groups in general. He also suggests that future research consider how self-efficacy evolves over time. Even though many studies identify factors that mimic or are strongly correlated to self-efficacy beliefs few have considered the development of these beliefs as multiple, fluid "snapshots" over time in empirical research.

Berry & Thunder's (2012, 2015) qualitative metasynthesis on black learners in mathematics has provided a shifting lens to understand more temporal aspects of research on identity development. In Berry & Thunder (2012), the authors focus on the negotiation of black learners' identities in multiple settings and also provide a brief review of factors that contributed to their identities over time. They conceptualize student experiences in mathematics as *racialized* forms of experience. They provided an extensive review of research studies focused on black learners in the K-12 setting and position a counter narrative approach focused on assets versus deficits. The authors throughout both studies deal explicitly with the concept of temporality and examine specific components of prior research using qualitative methods to understand the complex structure of factors contributing to adolescent identities. They extensively review distinct as well as overlapping findings provided by other researchers.

Looking across time both in and out of school specifically, Berry & Thunder (2012, 2014) identified a host of studies that detailed the experiences of black learners across school-based contexts. The contexts that they examined were those that allowed students to persevere in mathematics over time. As a result, they provided a framework to aid in understanding the defining qualities of learners' pathways. In this framework, the authors utilized a "step" feature in which access to academic choice and expectations provided the bases in which students' decision-making and self-evaluations were based on "radicalized forms of images" and "sustained by work ethic of practice and persistence" (Berry & Thunder, 2012, p. 21). This overall process is supported by values and shifts occurring in moments of "non-success," which ultimately are structured into success as students' decisions are continually sustained. This view provides a key narrative in which to understand the time-aspect surrounding identity development and the ways in which self-beliefs and self-evaluations mitigate the identity development process. Next I draw more specifically on the contexts that inform the self-evaluative process during the identity development trajectories of black learners in mathematics.

Some researchers in particular (e.g., Berry 2005, 2008; Noble, 2011; Stinson, 2006, 2009) include direct links to all of the variables analyzed in this research, with sex being a defining feature of each study. Noble (2011) has been discussed earlier in this chapter, specifically in relation to Bandura's SCT. In Berry's (2005, 2008) examination of the experiences of African American middle school boys, I found his attention to the factors that contributed to their entry into upper level mathematics most applicable to this study. In his study, Berry (2008) found that five factors were consistent across the students examined. These factors were positive early experiences in school and with mathematics, recognition of abilities as a result of being placed in higher tracked mathematics groups, family networks as the source of opportunities, standards, and resources, the presence of positive mathematics and academic identities, in addition to the presence of additional alternative identities related to a host of school and non-school activities. The links connecting the sources of self-efficacy and Berry's findings are clear. Further, the contributing factors, such as positive mathematics identities and early experiences of success contributed to these students' sense of a mathematical self. Like Thompson & Lewis (2005), who studied an African American male who petitioned for an advanced mathematics course in his school, the students in Berry's (2005, 2008) studies held positive self-images toward their mathematics abilities. In this study, I argue that these positive self-images toward mathematics rest at the intersection of positive mathematics self-efficacy beliefs and mathematical identities. Stinson (2006) focused on the experiences, or enactive attainments, of African American males in mathematics and noted the importance of achievement discourses during the development of practices in mathematics education. These discourses outlined by Stinson and others (e.g., Jett, 2012;

Leonard & Martin, 2013; Moody, 2000, 2004) have been situated in the research on the development of African American students' academic identities and mathematical identities within the literature. Stinson's (2006, 2009) contributions provide key theoretical frameworks to help readers come to a better understanding of the complexity of mathematics and schooling as it relates to identity and achievement orientations. There is still a lack of research at the K-12 level that focuses heavily on the experiences of black female learners (Borum, 2012; Gholson & Martin, 2014). Although these three researches focused exclusively on black males, the findings have general implications for the models developed and subsequently examined across both male and female sample populations.

The literature in education and mathematics education point to a host of indicators that inform the development and construction of students' mathematical identities (Berry & Thunder, 2015; Nasir & Cobb, 2007) but less research on the development of their self-efficacy beliefs (Berry & Thunder, 2012, 2015; Noble, 2011; Spencer et al, 1993). In connecting these factors, I found it important to examine their effects and subsequent implications using quantitative methods. First, no nationally representative quantitative studies, to my knowledge, have examined temporal shifts in black students' identities and their self-efficacy beliefs in mathematics during secondary school. The modeling techniques employed required the creation and generation of correlates to identity and self-efficacy research that helped to explain differences in students' experiences. Berry & Thunder (2015) found the following five areas which contributed to students' perseverance in mathematics: "(1) learners develop identities based on values which were offered by others with whom they interacted, (2) learners negotiated their own definitions of success, (3) learners encountered issues of awareness and access along their pathways, (4) learners negotiated pathways to persevere in mathematics at the intersection of racial and academic images, and (5) learners with a high sense of agency persevered with mathematics across time" (p. 11). I utilized these five areas to focus the literature search on correlates of identity and self-efficacy in mathematics.

2.4 CORRELATES OF IDENTITY AND SELF-EFFICACY IN MATHEMATICS

The correlates of identity—broadly defined—along with Bandura (2001) and Noble's (2011) presentation of self-efficacy result in a list of factors at the intersection of psychological and sociological approaches to identity (Côte & Schwartz, 2002). The varied approaches have generally contributed to difference in their function and discussion of these factors in the literature. These correlates generally surround a focus on student belongingness and engagement in practices, with their peers, teachers and others, that are supported by supportive learning environments, an arrangement of opportunities, and high expectations. Together these factors contribute to students' sense of community and perceptions of task importance in terms of their "fitting in" and "standing out" (Gray, 2014). The research in this area has shown their significance across many contexts and findings have varied. As a result, studying the function of a host of related factors and their interrelation is warranted.

Explanations related to "psychological functioning involve a continuous," or discrete, "reciprocal interaction between behavioral, cognitive, and environmental influences," (Bandura, 1978, p. 1) making self-efficacy an integral component in the study of the construction of African American students' mathematics identities. The inclusion of moderating influences is necessary when examining students' self-efficacy beliefs alongside their developing identities. Researchers have identified the fundamental contributions of self-efficacy beliefs to agency, motivation, learning, and academic achievement (Bandura, 1986, 1997, 2001; Boykin & Noguera, 2011; Noble, 2011; Pajares, 1996, 1997; Pajares & Graham, 1994; Pajares & Miller, 1994, 1995; Schunk, 1991, 2006; Spencer et al, 1993; Spencer & Markstrom-Adams, 2005). Those studies specific to African Americans' self-efficacy beliefs and motivation have provided critical extensions of this literature to the current population of study (Graham, 1992; Jonson-Reid, Davis, Saunders, Williams, & Williams, 2005; Noble, 2011; Spencer et al, 1993). However, there is still a dearth of research on African American youth that contributes to our understanding of African Americans' self-efficacy beliefs and integrates these perspectives as a primary marker of identity development processes (Spencer, Fegley, & Harpalani, 2003).

Seminal and contemporary research has focused on the experiences and trajectories of black learners at the intersection of identity and cognition (see, for example, Fordham & Ogbu, 1986; Spencer, Dupree, & Hartmann, 1997; Nasir, 2005; Steele, 1997). Researchers have commented on the importance of integrating socio-cultural and social cognitive perspectives in the literature on identity development (Nasir, 2005; Spencer, Fegley, & Harpalani, 2003). In the following sections, I discuss a host of correlates that help to generate discussions based largely on the communal nature of learning and the cognitive work that occurs within these processes (Nasir, 2005). As a result of including these factors, I was able to generate a host of models to hypothesize their structure in mathematics identity development.

Peer Networks

There has been an extensive body of empirical research focused on peer networks and their influences on student cognition, behaviors and academic outcomes (Harris, 2010; Schunk & Hanson, 1985). Harris' (2010) review of the peer research literature across fields states that "social scientists have long been interested in how the behavior, beliefs, values, and educational outcomes of children are shaped by interactions with peers in school activities" (p. 1164). Harris (2010) notes that "it [is] impossible in a single article to discuss a wide range of theories, their implications, and evidence…[as they] are likely to be the product of different types of social processes" (p. 1166). As a result, I examined studies that provided a comprehensive or connected view upon which to analyze students' perception of their peers. In doing so, I was able to integrate additional factors as controls to narrow in on students' *perception* of the composition of their peer networks.

Jencks & Mayer (1990) reviewed peer effects through the epidemic or contagion theory of peer influence. Epidemic theory suggests that schools and institutions have a dominant ideology and set of norms that students try to conform to; namely, students may emulate the behavior of subgroups versus the entire institution. Those students who hold a high sense of individuality and self-identity, or agency, may rely less on these groups per theoretical contributions in this area. Harris' (2010) take on Jenks & Mayer's use of epidemic theory of peer influences is that children emulate the behavior of their peers on the sole basis of peer group norms. Academically and socioeconomically advantaged peers are more likely to engage in academically oriented behaviors and view tasks, such as homework, as more important from this lens. In some ways, this is connected to the “bad apple” theory, which is reiterated by Harris (2010). This theory situates itself around a very rigid view of academic achievement. The “bad apple” theory focuses on deficits and positions disadvantaged students as having negative effects on the achievement of their peers. Contrastingly, a “shining light” student raises the achievement of their peers (Harris, 2010). In many ways, this rhetoric leads us back to Martin’s (2009a) caution regarding the use of seeming pseudonyms in language when discussing race and class in education. Further these linear conceptions may not fully recognize the complex structure of peer interactions and the many ways in which students’ peers may shift their school belonging (Gray, 2014).

Fordham & Ogbu’s (1986) “acting white” hypothesis relates to Jenks & Mayer’s (1990) conception of epidemic theory, which have received mixed reviews from the research community (see, Ainsworth-Darnell & Downey, 1998; Harris, 2006; Horvat & Lewis, 2003). The Oppositional Culture Framework (Fordham & Ogbu, 1986; Ogbu, 2003, 2004) and Ogbu’s cultural ecological theory was framed as a mechanism for black students to cope with the burden of “acting white” and was identified by Fordham & Ogbu (1986) as a major factor in explaining black students’ school performance. The notion of “acting white” surrounds the social pressures black and Latino/a students have that are involved with striving for academic success; Jenks & Mayer (1990) call this cultural conflict.

However, Horvat & Lewis (2003) specify that the “oppositional culture” theory does not allow for diversity in the types of peer interactions that black students experience. Namely, they believe the theory undermines those students of color who strive for academic success and labels them as “anomalies” (p. 267). Horvat & Lewis

(2003) also noted that the theory counters the fact that there are students who utilize their peer networks for academic success and support. In order to provide an alternative understanding to this “oppositional culture” frame, Horvat & Lewis (2003) conducted a study at two urban high schools in California. Observations totaling 200 hours were conducted at the two school sites. A series of interviews and additional observations (some at special school events) were also conducted. Findings indicated that students in were able to manage academic success through many different ways. One way in which they managed academic success, formerly posited by Fordham & Ogbu (1986) as “camouflaging,” was to play down their success. However, Horvat & Lewis (2003) did not find the type of opposition or “students being ostracized by their peers” (Horvat & Lewis, 2003, p. 269) that was originally placed in Fordham & Ogbu’s theory. “Playing down” their academic success, in contrast, was described as students having a sense of agency to “negotiate multiple standards of success” (Horvat & Lewis, 2003, p. 271). The authors found that the students in their study also shared their academic success with supportive peers. The “oppositional culture” theory utilizes race as one of its primary markers in its “acting white” hypothesis. Horvat & Lewis (2003) found that students in their study had a very strong racial identity and were able to maintain friendships with both black peers who were not as successful and white peers within and outside of school. In their discussion, Horvat & Lewis (2003) mentioned that “characterizing the black peer group as a homogenous collective that is opposed to academic excellence has led researchers to forgoe the heterogeneity of the black peer group and the differential effects and influences that friends and peers exert on the academic strivings of black students” (p. 275). Thus, extending support for researchers to account for variance within peer interactions. In order to frame students' interactions from a lens that is not focused on a unfavorable notions of peers—or a deficit view—especially for black students, an examination of the literature situated more generally around friendship groupings is needed. By examining these groupings, more specific references within a positive frame that detail out peer interactions for black and Latino/a students can be made.

Datnow & Cooper (1997) found that peer networks among African American students in elite independent schools that were predominantly white supported students' academic success and allowed opportunities for students to negotiate their success through racial affirmation and identity. Horvat & Lewis (2003) and Datnow & Cooper's (1997) findings suggested that peers play an important role in black and Latino/a students managing success. This has been found in other research on peer networks in mathematics education as well.

Walker's (2006, 2012) research on urban students' academic communities and their role in aiding students to facilitate academic success in mathematics moves the peer network relationship closer to discussions of identity and mathematical proficiency. Walker examined peer influences and the cultivation of mathematics success based on relational aspects of the networks within their communities. She made use of Phelan, Davidson, & Yu's (1998) "multiple worlds" framework. Phelan, Davidson, & Yu (1998) and Phelan, Davidson, & Cao (1991) generally situated students' experiences within school and outside of school as being more manageable if these experiences were congruent or less-so if they were not—peers helped to make this transition more manageable. This framing related to Carter's (2006) work on students "straddling boundaries" and the effects of school culture on students' identities and academic dispositions. In supportive environments students generally flourish when supportive relationships are present at home, with peers, and at school with teachers and other personnel. These factors help students more easily manage their expectations. If one of the environments is more inconsistent and requires the student to figure out an effective way to manage the transition, it has an impact on students' reactions to various situations.

Walker (2012) examined the experiences of mathematically high-achieving black and Latino/a students where, for some, congruency existed and for others it may not have. Findings from Alexander & Walker (2011) and Walker's (2012) research supports claims made about academic peer networks and frame the discussion within mathematics. Namely that there are variations in students' peer interactions and these experiences are largely positive. Both Alexander & Walker (2011) and Walker (2012) found that support structures across adolescent intellectual communities that were not originally framed by students as academic support structures. For example, one student, John, in Walker's (2006) study noted that "he and his friends didn't talk about their mathematics work" (p. 59) but after more investigation, Walker found that John and another student, Damon, actually worked together when something in their mathematics classes came up that one of them did not understand. She noted that students' intellectual communities aided in their success in mathematics but may extend outside of their friends—and this reciprocal support among high achievers may not always be captured using traditional research approaches. Walker's (2012) findings are pertinent to gaining a contextual understanding of peer interactions and their implication for students' mathematics identity development.

Goodenow (1992) discusses how education is a social process and depends on various relations that help youth attend to shifting identities during their developmental stages. A version of evidence of these social processes is noted in Walker's (2006) findings. The social interactions that students experienced were not rigid shifts between contexts but instead imbedded contexts that sough to support an overall academic identity. Goodenow argues that understanding the social contexts and group processes are an important part of educational research, especially when it involves psychology. Students negotiate "multiple worlds" (Phelan, Davidson, & Yu, 1998) and in doing so various factors such as social dimension, self-identity and group dynamics will impact their individual learning and overall motivation. Cooper, Jackson, Azmita, & Lopez (1998) also utilize a multiple selves, multiple worlds framework and present strategies that can be used by researchers to examine identity development. They note that theories that seek to increase adolescent autonomy are missing in the literature. Ones that do, as Cooper et al (1998) argue, provide a wide range of opportunities in which adolescents can explore various outcome related identity-development processes.

The function of peer networks and peer groups of various personal peer connections from multiple contexts is undervalued in education research today. In adolescence, peers play an extremely crucial role in youth personal, social, and emotional development. The complexities of networks and kinships are unique to the dynamics present in the student context based on classroom and peer group composition. Peers, on the one hand, are the individuals with whom students experience many things with for the first time and for whom they confide in, as well as utilize as support systems in school environments. On the other hand, peers can complicate developmental processes, this happens along the entire life course. All of these forces play a role in the development of beliefs. As such, the majority of interactions between peers in the adolescent years take place, seemingly so, within educational settings and community spaces often regarded as sites of informal learning.

School Engagement and School Belonging

Conceptual frameworks related to school engagement and belonging focus on students' emotional investments in behaviors that support their continued engagement (Goodenow, 1992, 1993; Gray, 2014). While research on school engagement among students of color has most often focused on the contexts of absenteeism and dropout rates, the frameworks presented in these studies link to larger theoretical conceptions that tie into academic success and youth developmental theories (Noguera, 2003, 2008). Noguera (2008) conducted research on correlates of belongingness focusing exclusively on black and Latino males. His work details the links between social and cognitive factors contributing to differences in a host of social-emotional and academic outcomes. Sirin & Rogers-Sirin (2005) found significant sex differences between males' and females' school engagement in a quantitative study on engagement among African Americans. The authors focused more exclusively in their study on whether or not a student felt "good" in the school environment. In their study they noted that identification with school was not significant as a precursor. This is in contrast to Steele (1992) and Osborne's (1997) conceptions of African Americans' levels of reported engagement and associated belongingness. There has continued to be a dearth of connected research on African American females in this area (Steele & Aaronson, 1995). Gender and sex based differences in students' experiences contribute to further variation in their sense of self-efficacy and their identity development in mathematics, as engagement and identity development have been previously linked to gender in education contexts (Alexander, 2013; Noguera, 2008).

Steele (1992) linked identification to school as integral to school engagement among African American students. In his study, Steele focused on the emotional aspects of school engagement for African American students and noted that they can disengage with school even when knowledge, skills and resources are present. This identification can be situated within a conceptual framing of school belonging. School belonging and school identification are not synonymous in how they are conceptualized. However, the concepts correlated with the likelihood of perceptions of stigmatization and self-esteem in school environments where academic outcomes were a focus (Steele, 1992). In the cases where these perceptions are negative or low, disidentification may present itself as a form of insulation, specifically from, for example, a lack of feeling that successes are acknowledge or for fear of having their failures at the fore. These are conceptualized in terms of net stress (Spencer, 1995; Spencer et al, 1993).

Osborne (1997) focused on the intersection of race and the notion of academic disidentification. In his study, he found that African American males remained disidentified with school through grade 12 in large part due to a "system of schooling that causes African Americans to disidentify with academics" (p. 728). Osborne points to systemic issues that related social and cultural norms as impacting students' sense of school belonging and academic identification. Osborne (1997) noted that no other racial group or sex demonstrated a significant level of disidentification as black males did. He tested assumptions from Steele's (1992) study using correlation analyses noting that although racially minority students do not have lower self-beliefs they "perform more poorly in academics than whites" (p.730). The links made between Steele's (1992) and Osborne's (1997) work link sociocultural and social cognitive perspectives.

Sociocultural perspectives on school belonging provide a link to student learning and achievement that helps to explain outcomes from a more macro level. This is in addition to their identity development and intersects with many of the factors that help to inform developmental trajectories among adolescents. While findings on school belonging have varied for African American students for various reasons, studies have generally found that the significance of school belonging is central to many school-related outcomes. Teachers and peers play vital roles in the development of students' sense of belonging in school contexts. School belonging is as a result central to the study given the focus on other contextual factors such as the mathematics learning environment and peer networks.

Goodenow (1993) identified school belonging as a critical component to the learning process. In other studies she has discussed the importance of linking psychological factors to social contexts (Goodenow, 1992). Belonging is often defined as the extent to which a student feels accepted and included in the school social environment (Goodenow, 1993). The concept of school belonging is positioned within the *belongingness hypothesis* which posits that humans seek to "form and maintain...lasting, positive, and significant interpersonal relationships" (Baumeister and Leary, 1995, p. 497). School belongingness is connected to self-efficacy in a number of ways. In Goodenow's (1993) research, school belonging is strongly related to psychological membership and a students' perception of membership. Membership has an affect on cognitive development in school contexts thus linking the concept to the cognitive processes outlined in the relationships between learning goals and identity development (Nasir, 2005). Extensive research on school belonging has shown that the concept in itself may transcend racial-ethnic and gender bounds, as a sense of belonging is a central component to the human experience. Research on school belonging for African American youth has provided additional contexts to help examine the interaction of psychosocial factors with other key variables, such as students' learning environments and their feelings of belongingness.

Booker's (2006, 2007) research on African American students' sense of belonging has contributed to understanding student school participation, particularly in classroom environments. Booker (2007) found that African American students' participation in classrooms were directly related to their sense of belongingness and helped to inform student achievement. Similarly, Booker's (2006) study noted that African American students' sense of belonging was significantly related to teacher support, peer network relations, engagement, and academic performance. The link between these various contextual factors points toward the continuing need to investigate how students' identity development in school links to their perceptions and beliefs about their abilities in specific learning contexts. Moreover, understanding how these contextual factors impact students' perceptions and support or deters their developmental trajectories is useful to the research community. These findings noted by Booker (2006) were in contrast to Uwah, McMahon & Furlow's (2008) study on African American male students' school belonging. In their study, Uwah et al. (2008) examined the relationship between school belonging and self-efficacy, among other factors; no significant relationship was found between the two variables. However, the researchers did find a significant relationship between the encouragement of others, such as students' peers and their self-efficacy beliefs. These particular findings overlapped with some of Booker's (2006, 2007) research findings and warranting further investigation.

Uwah et al (2008) contended that although self-efficacy is largely considered an individual cognitive variable, it has a link between students' sense of belonging and their connectedness to their learning environments. The authors hint to a reciprocal relationship between sense of school belongingness and self-efficacy. Goodenow (1992) supports this connection by stressing the importance of linking education psychology to social contexts as a means to understanding individual experiences. These findings point to the importance of conducting additional research on school engagement and sense of school belonging with regard to learning contexts, particularly classrooms. Further, the social connection in terms of teaching and learning is related to students' perceptions of their teachers within the learning environment.

Mathematics Learning Environment

Mathematics classrooms have been long identified as a very segregated space in the United States (Stiff & Harvey, 1988; Tate, 1997). Students in today's schools and classrooms are often segregated by race and socioeconomic status and these differences become more apparent in advanced courses (Oakes, 1987, 2005; Riegle-Crumb, 2006; Walker, 2009a, 2009b). This now apparent and well-understood issue has contributed in many ways to the focus on "achievement gaps" in mathematics (Gutiérrez, 2008).

Ladson-Billings' (1994) research on successful teachers of African American students provides a base-level outline that is familiar to many researchers in interested in the function of race in mathematics education learning and teaching. The work conducted by Ladson-Billings (1994) has been used widely by the research community as a primer to improving education through authentic instructional practices. Noticing that there has been little done to make pedagogy one of the central areas of investigation in research, Ladson-Billings (1994) takes an in-depth, fully rounded exploration of the practices of successful teachers of primarily African American children. In her observations, she examined the pedagogical, cultural, and community practices of these teachers. Ladson-Billings (1995) defines and recognizes culturally relevant pedagogical ways of being that have proven successful in increasing not only the learning and performance of African American students in classrooms. Findings from her investigations incorporated teachers' need to bridge culture into the teaching and learning process and shifting the stereotypes held about diverse student populations and their abilities (Ladson-Billings, 1994, 1995, 1997). This research has been more recently focused on sustaining students' cultures and individual backgrounds—via Culturally Sustaining Pedagogies—in classroom contexts and increasing levels of authenticity and agency as employed both by student and teacher (Ladson-Billings, 1994, 2014; Paris, 2012).

Hilliard's (2003) focus on achievement and excellence among African Americans synthesized literature concerning black students in various academic contexts. While not focusing specifically on mathematics, the central idea of his work focuses on the fact that youth are capable of achieving excellence if provided the necessary pedagogical tools and authentic care. Moses and Cobb's (2001) approach to excellence through improved math literacy and civil rights has prompted programs such as *The Algebra Project* and connected organizations like *The Young People's Project*. These are organizations that work directly with students to develop critical thinking skills as a vehicle through mathematics. They have also provided contrast to the images traditionally presented in the teacher education literature.

Differential access to mathematics opportunities for secondary school students is a function of early access to opportunities. Early access contributes significantly to future outcomes (Davis, 20003; Riegle-Crumb, 2006). Gutiérrez (2000) evaluated the school staff and documents to understand what specific components of the mathematics department seemed to support students in their development and continued enrollment in advanced courses. She examined supports in relation to students' enrollment in and progression through advanced mathematics courses. Findings from the study suggested that active and early commitments to high outcomes for students in teaching practices and school structure based on standards and supported by a level of rigor that is both challenging and engaging helped students in their mathematics development. Course offerings and curriculum materials play a key role in the opportunity to attain advanced mathematical skills and concepts. "Teachers' perceptions of their students" as found by Walker (2009b), "affect the type of curriculum, instruction, and assessment teachers offer." (p. 7). This suggests that educators understand the additional forms of support that students have present in their lives.

Sex

Scholars have identified the importance of research on sex that differentiate the experiences of African American females and males and use these models to inform practice (Jackson & Moore, 2006; Thompson & Lewis, 2005). In line with a focus away from deficit-oriented approaches in mathematics education research (Gutiérrez, 2008), the work on sex differences in this area pulls largely from literature employing critical perspectives to frame student experiences in mathematics and education in general (see, Berry, 2008; Gholson & Martin, 2014; Oakes, 1990; Stinson, 2008). While there is a host of research examining both black males and black females in the research literature, there continues to be a dearth of this literature in the domain of mathematics education. Noguera's (2008) framing and exploration of issues faced by black youth in urban cities begins by examining the compounding impacts of race and inequity within schools and classrooms—thus, making a case for more research focusing on the intersection of race and sex.

Hrabowski, Maton, & Grief (1998) examined how African American males overcame obstacles and expectations generated by statistics and provide suggestions for raising academically successful males. Hrabowski, Maton, Green, & Grief (1998) provided a similar space for understanding the experiences of and strategies for African American females in science and technology, fields usually grouped with mathematics and engineering in a STEM context. While the focus of these books is not directly related to mathematics and mathematics education, they allow us to think about the function of sex in relation to power and structure across the educational pipeline. By taking into account these and other texts (e.g., Borum, 2012, Harper & Nichols, 2008; Tillman, 2002) there is a clear description of a need to increase research on black students from non-deficit frameworks and especially on females, since research on black females in K-12 mathematics is lacking. There is, however, a systematically examined literature review on sex in science education (Brotman & Moore, 2008).

In their review, Brotman and Moore (2008) identified four themes pertaining to girls' engagement in science, which help to frame similar content based on sex in mathematics education. The four themes identified by Brotman and Moore (2008) were as follows: (1) equity and access, (2) curriculum and pedagogy, (2) the nature and culture of science, and (4) identity. Throughout their review, the authors identified a host of tangential issues that researchers have discussed in previous texts focused on sex and mathematics. The first theme, equity and access, was about "identifying classroom biases and inequities as well as differences in girls' and boys' achievement, attitudes, participation, and experiences in science" (Bortman & Moore, 2008, p. 980). This theme also included strategies to help promote and ensure girls' equal access to science. The second theme of the study, curriculum and pedagogy, "investigated girls' learning interests in science as a basis for curricular adaptation" and looked at examples of inclusiveness (p. 982). The third theme, which focused on the nature and culture of science, argued that student engagement in science, especially girls' and other marginalized groups, was based upon a need to challenge portrayals of science—which have a direct link to mathematics and its conceptions in broader society. The last theme, identity, helped bridge the literature in science education with the current study. Namely, the authors focused on identity and the role it plays "in students' engagement with and learning in science" (p. 988). An integral part of their conception of identity was the idea that sex is an important, though not singular, part of identity and identity development. The authors emphasize within-group sex diversity and how literature and practices can extend beyond simplistic binary operators of sex, especially as they relate to gender.

As was the case in science education, sex inequality in mathematics has similarly been a longstanding issue both nationally and internationally (Alexander, 2013). While a host of issues surrounding sex and females' participation in STEM fields, and specifically mathematics, there are contexts that help to further define what women and girls face with regard to the study of mathematics. Alexander (2013) and Borum (2012) noted that historically women have been given limited access to mathematics, which set up a stratified system of participation in the field very early on. Brotman and Moore (2008) discuss these contexts in science education. A further extension beyond sex and gender-based discrimination is the reality that black women were also faced with racial discrimination as well (Borum, 2012). However, in her study of black women mathematicians in the United States, Borum found that women identified support structures that helped to support mathematics identities was a primary mechanism in achieving mathematics success. This theme was also found in Brotman & Moore's (2008) review of girls and science in the literature. These are important findings that have been discussed in the literature for both black females and black males in mathematics; less research has been conducted with regard to black females.

Berry (2005, 2008) discusses stories of success among African American middle school males in mathematics. His qualitative research study, employing critical race theoretical and phenomenological frames, reviews the factors that other research scholars have identified as contributing to African American boys' success in school mathematics. These factors, as outlined by Berry (2008), are: (1) positive rapport with caring teachers, (2) previous exposure to rigorous mathematics, (3) standards-based instructional practices, (4) positive academic and social peer interactions, (5) positive self-image toward mathematics and school, (6) a countering of negative images of African American males, (7) advocacy from adults, (8) role models, (9) racialized experiences (Berry, 2008, p. 466). Stinson (2008) provided a parallel frame of understanding but from an inquiry based perspective situated around historical research and his participants' schooling experiences. Stinson documents the "counterstories," namely stories that counter master narratives in the research literature about African American males' abilities in mathematics, of four academically and mathematically successful African American males. Notable in these empirical investigations is a shift away from deficit perspectives and a focus on success in mathematics among black youth (Leonard & Martin, 2013).

In his study, Berry (2008) found that the early educational experiences were consistent among his participants path to success. Along with these experiences was a clear recognition of academic abilities. Recognition of these abilities aided in students' development of alternative identities. These identities subsequently provided a more positive mathematical and academic identity that had been and were continually supported in large by students' academic communities (Walker, 2006, 2012)—more specifically, their parents, teachers, family members and friends. Stinson's (2008) study provides an additional lens of understanding and more complete view of Berry' (2008) notion of alternative identities. Stinson focuses on the rejection and reconfiguration of his four participants' negotiation of negative African American male images, both within mathematics and in general. Permeated throughout the participants' stories were huge tenants of race and what is most notable is the potential connection to sex.

While there are research studies that look at sex in mathematics education and discuss the experiences of black and Latino males, it is the social and cultural discourses added to these gendered experiences that make it central to this dissertation study. On a different sample of black male youth, Terry & McGee (2012) found that there are a host of school and classroom supports that help to raise males' achievement outcomes. In addition to many of the supports outlined by Berry (2008), the authors (Terry & McGee, 2012) identified the importance of fostering "mutually encouraging, culturally affirming competitive excellence as a defining characteristic" in schools and classroom environments, such as mathematics classrooms (p. 80).

Thompson & Lewis (2005) conducted a case study on an African American male, Malik, and investigated his previous mathematics achievement and career attainment goals. The authors frame their study in line with components of success and away from notions of failure and underachievement. Malik is of special interest in this particular study because of his interest in taking advanced mathematics courses in high school, one that he had to petition for. His telling of the mathematical experiences and its relation to his career attainment provided a perspective not often presented in the research literature, media or public spaces of African American males. The impetus behind Thompson & Lewis' (2005) retelling of Malik's story came from Garibaldi's (1992) sentiments that a public telling of success, particularly for African American males, increases students' "self-concept, self-esteem, and academic confidence" (p. 7).

Oakes (1990) furnishes an informative outline of the participation of women and minorities in mathematical, scientific, and technological fields since the late 1980s in a review of the literature. Focusing on under-representation to underutilization in mathematics in science, Oakes also examines the lack of promise that participation, representation and utilization will increase as noted in research literature. In regard to women, specifically, Oakes states "losses among women occur primarily at the end of pre-college years and during college" (p. 160). The literature examining this integral period for African American women help to underscore the presence of sex discrimination in mathematics.

Steele's (1997) work on stereotype threat, specifically relating to African American women in areas of advanced quantitative reasoning (e.g. mathematics, engineering, and the physical sciences), presented a clear theoretical case for empirical research to be conducted to better understand how sex, gender, and race can impact identity and performance. Steele's earlier work with Aronson on stereotype threat (Steele & Aronson, 1995) regarding African Americans performance on tests is clear evidence that personal characteristics such as sex can have an impact on performance, especially in STEM fields where underrepresented populations are perceived by dominate stereotypes to lack in ability. Steele & Aronson (1995) examined stereotype effect in four controlled experiments between black and white college students. Findings suggested that when issues of race arise and beliefs of poor performance are made salient, students' performance reduced on standardized examinations. The authors found that stereotypes have the ability to disrupt performance and produce doubt in an individual's beliefs about their performance capabilities. Steele (1997) provides the theoretical structure for these findings and produces a more general argument based on components of personal identity.

More recently, Gholson & Martin (2014) examined the complex and under examined structure of learning mathematics for African American girls in a third-grade class through the lens of students' peer networks. The authors found, similar to Walker's (2006, 2012) research on academic communities, that students' social networks played a significant role in their opportunities to learn mathematics. Further, they found that these networks helped to inform identity development processes for the students. Based on their findings, the authors highlighted the nuances attached to black girlhood in social and learning contexts and how these nuances generated variance in students' identities. Specifically their "framing suggests that the intersection of different identities confers unique privileges and disadvantages in different situations and contexts," generating an "elastic, eclectic, and useful construction for understanding the life experiences of black girls" (Gholson & Martin, 2014, p. 32). Like Brotman and Moore (2008), the authors further underscore the complexity of identity development and how various notions of the *self* help to inform the development of students' identities.

Tucker (2000) utilized an empowerment perspective as a means to situate African American females' success in mathematics. She noted the importance of high levels of quantitative and analytical skills needed to study mathematics at higher levels but focused on the factors of socialization, sex inequities, and racism faced by African American females as a primary reason why achieving such skills is such a difficult task. Some of the accounts noted by Tucker (2000) are tangential to the issues faced by the women in Borum's (2012) research on women mathematicians. Specifically, Tucker noted that the Self-Empowerment Theory of Achievement (SETA) would help to provide success among African American female children. This framework encompasses the following, as described by Tucker (2000): "(a) being motivated to learn and compete in math, (b) engaging in self-control and using learning methods that minimize frustration and fear of failure that can deter from success in math, (c) using self-praise of the efforts and success experiences involved in learning math, (d) learning and using adaptive skills that promote use of and appreciation of math (e.g., how to balance a checkbook), and (e) engaging in success behaviors for success in math (e.g., studying math daily and paying attention in math class)" (p. 144). While many of these factors seem to place the onus on young females to inform changes, which is in opposition to the themes noted by Brotman and Moore (2008) who focus on structural changes that aid in students' identity development, Tucker (2000) presents an extension to the compelling cases that point to a host of issues with regard to young African American females' opportunities to fully engage and learn mathematics. However, given that the amount of research looking specifically at these issues in mathematics for young black women is lacking, more empirical studies that examine similar questions are necessary.

Study Hypotheses

Based on a comprehensive review of the literature, primarily cited in this chapter, a set of hypotheses was generated for this study. The below hypotheses helped to develop a framework, the *Mathematics Identity-Efficacy Connection,* which is outlined in the next section and explored further in the concluding chapter. The hypotheses for the research study are presented below.

Study Hypotheses

Hypothesis 1: Students' perceptions of their peer networks will have a significant effect on their self-efficacy beliefs and identities in mathematics, in addition to other contextual factors, such as their sense of school engagement, belonging, and learning environments.

Hypothesis 2: Students' school engagement will be significantly related to other contextual factors, in addition to students' self-efficacy beliefs and identities, but especially their sense of school belonging, peer network, and their learning environment.

Hypothesis 3: Students' sense of school belonging will be significantly related to their self-efficacy beliefs and identities, in addition to other contextual factors, but especially their school engagement, peer network, and learning environment.

Hypothesis 4: Students' perceptions of their mathematics learning environments will be significantly related to their mathematics identities and self-efficacy beliefs.

Hypothesis 5: Sex differences will exists across students' assessment of their beliefs, in addition to other affective variables, such as school belonging and engagement.

Hypothesis 6: Students' mathematics self-efficacy beliefs will be significantly related to their mathematics identities within- and across- grades.

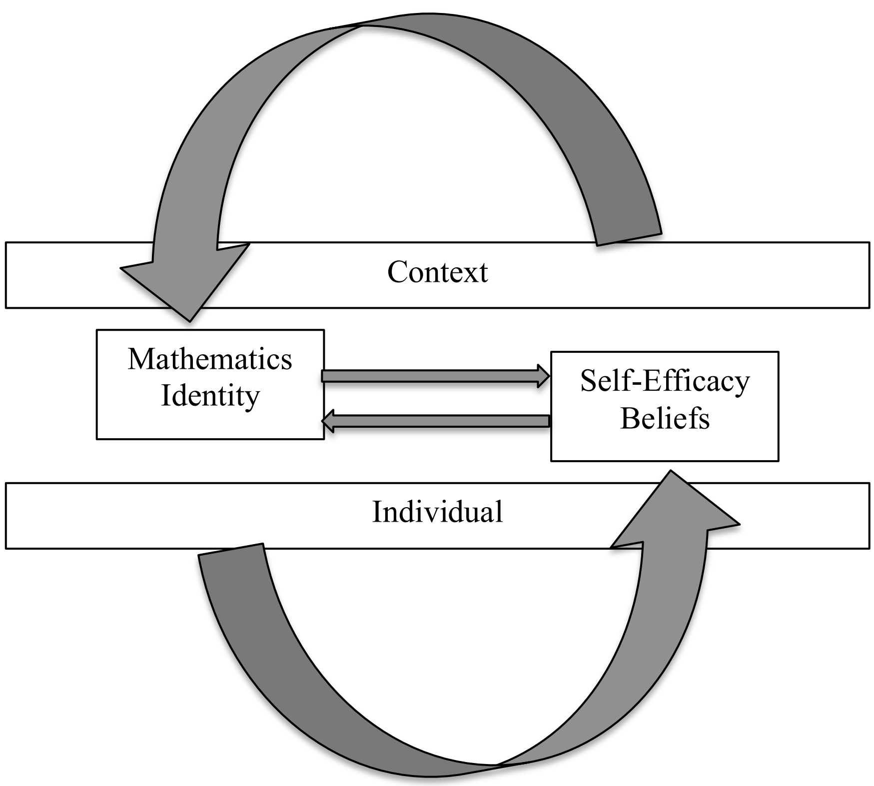
Hypothesis 7: Wave 2 measures of mathematics self-efficacy beliefs and mathematics identity will have a significant reciprocal effect on one another, in addition to a significant causal relationship with their respective Wave 1 counterparts.

2.5 THE MATHEMATICS IDENTITY-EFFICACY CONNECTION

Sociologist and psychologist agree that schools function as a primary site in which adolescents cultivate and validate their skills and abilities. I embed adolescent mathematics identity related processes within an in-school context to understand the strength of influences existing inside of the ecological model. To explore the study's hypotheses, I developed the *Mathematics Identity-Efficacy Connection*, which is based on an analysis of the related literature. I focused on the lenses that have helped to inform many of the contemporary perspectives related to the study of identity and self-efficacy, both in general and in the field of mathematics education. While noting the methodological approaches informed by said theoretical perspectives, I constructed an argument that attends to a need for an increase in interdisciplinary, and consequentially more nuanced, approaches to the study of sociocultural and individually centered perspectives in mathematics teaching and learning. The resulting *Mathematics Identity-Efficacy connection* provided a benchmark to explore the parallel construction of students' mathematics identity and self-efficacy beliefs. More specifically, the framework provides a means to understanding their relation based on theorized structuring within and across the grades.

The *Mathematics Identity-Efficacy connection* is presented to help structure possible processes in the parallel development of students' identities and efficacy beliefs in mathematics. In the framework, provided in Figure 2, I contend that a reciprocal relationship exists between the contexts and individual that helps to inform the development of one's mathematics identity. However, it is the mathematics self-efficacy construct that this reciprocity is largely supported by to foster students' sense of themselves as a "math person," i.e. mathematics identity. In the model, external factors help to structure the contexts that impact the individual and vice versa.

Figure 2. *Framework for the Mathematics Identity-Efficacy Connection*



As other context-based identities shift, mathematics self-efficacy beliefs help to inform students' ways of thinking both about themselves as someone who can *do* mathematics and their abilities *in* specific mathematical ways (i.e., I can solve this mathematics problem), allowing a more general frame upon which to discern efficaciousness which has an impact on their learning and long-term development. Furthermore, this relationship helps to base students' perceptions of how they think others located within a specific context view them: either as someone who can do mathematics or as someone who cannot do mathematics; alternatively, these conceptions can be held by individuals as perceptions based on identities more central to their core, where students perceive others to see them as a either a mathematical person or not one at all. In the framework, the individual student is functioning off of a context specific belief that informs the interrelation between their mathematics identities, i.e., identity-based in ones belief of being a "math person." In the following chapters, I present statistical models used to test the relationships between the central factors in the overlapping frameworks.

CHAPTER THREE

METHODS

The literature suggests that there is added value in understanding the development of identity and self-efficacy beliefs in mathematics, specifically as it relates to the individual structured in various contexts. The reviewed work strongly indicates that this value rests largely in an examination of external factors that contribute to student development both within and outside of learning settings. This chapter outlines the methods used to answer the research questions presented in the previous chapter and describes the data and analyses conducted to examine the relationships between self-efficacy beliefs and mathematics identity among black students within a U.S. context. This chapter includes a detailed description of the data, study participants, variables, analyses conducted, and delimitations of the study. The findings from the methods outlined herein are provided in chapter four.

3.1 DATA

Student data used in this study was taken from the High School Longitudinal Study (HSLS; Ingels et al, 2011; Ingels & Dalton, 2013). HSLS, as the study title suggests, is a longitudinal study containing information for students from their eighth, ninth and, most recently, 11th grade year of school. Each individual wave of HSLS was conducting using a nationally representative, two-stage stratified random sample (stage 1) and general random sample (stage 2). Schools were sampled at stage 1 and students at stage 2. Schools sampled included public, public charter, and private high schools offering instruction in both 9th and 11th grades during the base year (wave 1) of data collection in the fall 2009 term. Students randomly sampled were nested in all participating schools. As a result, two complete data files exist for HSLS: a school-level file and a student-level file. The publicly available student-level file was used for all analyses in this dissertation.

HSLS is focused on high school students' trajectories from entry into secondary school through their adult lives, in addition to a study of their high school environments and post-secondary expectations. HSLS focuses on mathematics and science education specifically and features an assessment of students' Algebraic skills. The instruments in HSLS that were relevant to the current study included a student questionnaire and a 72-item mathematics assessment in Algebraic reasoning, both of which were made electronic for the first time in history of studies conducted by the National Center for Education Statistics (NCES) (Ingels et al, 2011). Student participants completed the same 72-itemed mathematics assessment during both waves of data collection.

The questionnaire and mathematics assessment were administered in participating schools. The content of the questionnaire ranged from demographic data to questions related to students' "future locating and substantive questions" focused on their academic and life-long expectations (Ingels, et al, 2011, p. 7). The mathematics assessment was designed to provide a measure of students' algebraic reasoning at two different points in time (during 9th and 11th grade). The items on the assessment range in content and course-level. Specifically, the assessment included six algebraic content domains (language of algebra, proportional relationships and change; linear equations, inequalities and functions, nonlinear equations, inequalities and functions, systems of equations, and sequences and recursive relationships). The assessment also contained additional domains: algebraic ideas, performing algebraic reasoning, and solving algebraic problems. The assessment was conducted in two stages, the first portion completed by all students and the second being of three different forms of "variable difficulty" based on students' performance on the first portion of the assessment (Ingels et al, 2011, p. 7).

3.2 PARTICIPANTS

The population for the current study was black high school students in participating HSLS schools. Wave 1 student data was collected during students' freshman year (grade 9) of high school in the fall of 2009; wave 1 data includes representative information from 21,444 students (black and non-black) in approximately 944 schools across the United States. Wave 2 consisted of the same students from wave 1 and information was collected in a follow-up study during students' junior year (grade 11) of high school in the spring of 2012; wave 2 data includes a majority of the same variables and includes data for an approximately 2,000 additional students, i.e., N = 23,415. Data collected for students not included in wave 1 was coded as missing in the data file. Together, waves 1 and 2 created a nationally representative, longitudinal sample of students beginning high school in the fall term of 2009. Self-reported data on students' 8th grade mathematics courses and achievement in these courses was also provided in both data sets and used in the analyses.

The preliminary sample of black students for the present study was composed of 3,749 youth. There were 1,944 (51.85%) males and 1,805 (48.15%) females in this preliminary sample. To get this preliminary sample, I enacted exploratory analysis on students who identified as black in both waves (wave 1 and wave 2) of the study. To create a more racially homogenous sample, students identifying in any other racial-ethnic group were dropped from the analysis. In the preliminary sample, a total of 2,404 students identified as only black/African American, with 509 additional black students identifying as Latino and another 836 students identifying as multiracial. Additionally, there were 3 students who identified as black in wave 2 and, in wave 1, identified as multiracial. These students were dropped from the analysis. This reduced the preliminary sample of black youth to 2,401.

Further data reduction was required to obtain the final study sample. Participant identification at the next stage was primarily focused on dealing with missing data, specifically for students in the preliminary sample who lacked significant wave 1 data, student outliers in the preliminary sample, and students with too much integral data missing. Further, students who were not enrolled in a 9th or 11th grade mathematics course during data collection had to be identified, specifically due to the course specificity of mathematics self-efficacy questions in both waves. In these cases, student participants were dropped. There were a total of 1,362 students enrolled in mathematics courses during the fall 2009 and spring 2012 terms, when wave 1 and wave 2 data were collected; all other students who were not enrolled in mathematics courses during these periods were dropped. Thus, the final sample size was 1,362.

For students with missing information that did not fall into any of the prior categories, multiple imputation was performed using Stata's 13's mi command. Similar to Stata's routine MICE method (Royston, 2004), multiple imputation was used to create m = 5 complete data sets whose estimates were then "averaged across the copies to give a single estimate" (p. 227). These methods have been shown to provide more stable estimates in statistical analysis programs, such as Stata, when data are missing. Prior to imputation, and based on an analysis of data for student participants removed from the analysis, I was able to determine that there were negligible differences between the final sample and students dropped from the analyses in all moderating and outcome measures. Any additional missing data that was not imputed for any reason was replaced with the sample mean for the appropriate variable. The student sampling weights, w1student and w2w1stu, provided, respectively, in wave 1 and wave 2 data were used to generate necessary nationally representative data and analyze finding when appropriate. These weights, resultantly, produced nationally representative estimates for a well-defined sample of black youth who began high school in the fall 2009 semester and were enrolled in mathematics courses in the fall of their freshman year and spring of their junior year.

3.3 VARIABLES AND MEASURES

All observed variables and generated measures used in this study were obtained from student and parent self-report survey data, as well as performance data from the mathematics assessment, both of which were administered by the HSLS researchers. When necessary, data was confirmed by school records or parent responses by the original research team (Ingels et al, 2011). The models used in this study contained three observed independent variables: sex, socioeconomic status, and year of Algebra 1 enrollment; eight latent variables: mathematics self-efficacy (waves 1 and 2), mathematics identity (waves 1 and 2), academic peer network (wave 1), sense of school belonging (wave 1), sense of school engagement (wave 1), and mathematics learning environment (wave 1); and one observed dependent variable: Algebraic proficiency (wave 2). The measures included in this study have test and retest reliability from the original HSLS study (Ingels et al, 2011). Confirmation analyses were used for the self-efficacy and identity factors and most others were created using exploratory analyses. Specific details for these procedures are outlined below. Tables 1, 9 and 10 (located in the appendices) contain summary information for the study and latent variables.

Observed independent variables

Sex. Student sex was obtained from student self-report data using the HSLS variable x1sex. A dummy variable labeled 'female' was generated and coded "0" for male and "1" for female.

Socioeconomic Status *(SES).* A composite student-level measure of SES was obtained from parent self-report data. It was calculated using parent/guardian education (x1par1edu and x1par2edu), occupation (x1par1occ2 and x1par2occ2), family income (x1famincome), and derived using the student's school location (x1locale). The school location variable (x1locale) provided a more accurate measure of socioeconomic status based on urbanicity (e.g., urban, suburban, rural). Measures of urbanicity for this specific sampling were aligned with those from the Common Core of Data (CCD) 2007 – 2008 and the Private School Survey (PSS) 2007 – 2008 (Ingels et al, 2011). A composite construct labeled 'ses_u' was computed as the average of the imputed values from the outlined SES variables; the values range from -1.7526 to 2.5668, with higher values indicating a higher socioeconomic status.

Table 1

Study Variable Summary Statistics (n = 1,362)

Variable	**M (SD)**	**Min**	**Max**	**α**
Female	.495 (.500)	0	1	
Socioeconomic Status (SES)	-0.038 (.753)	-1.75	2.57	
Year of Algebra 1 Enrollment	1.896 (.599)	0	3	
Self-Efficacy 1 (MSE_{w1})	.178 (.858)	-2.78	1.47	.90
Self-Efficacy 2 (MSE_{w2})	.172 (.860)	-2.37	1.57	.89
Identity 1 (MID_{w1})	.044 (.845)	-1.51	1.46	.95
Identity 2 (MID_{w2})	.005 (.892)	-1.39	1.54	.98
Peer Network	-0.123 (1.694)	-3.44	3.23	.74
School Belonging	.164 (.955)	-4.35	1.59	.65
School Engagement	.053 (.939)	-3.38	1.39	.65
Learning Environment	.277 (2.251)	-8.26	3.44	.89
Algebraic Proficiency	48.34 (8.643)	27.27	79.89	

Year of Algebra 1 enrollment. School year of enrollment in Algebra 1 was used to measure the student's entry into the base course used on the dependent outcome variable, Algebraic proficiency. The variable s2alg1when is a self-report variable taken from wave 2 of the study. The variable yearalg1 was generated from the original variable. Values for this new variable ranged from 0 to 3. Zero indicated that a student had not yet taken Algebra 1, "1" indicated that a student HAD enrolled in Algebra 1 in 8th grade or before, "2" indicated that had enrolled in Algebra 1 in 9th grade, and "3" indicated that a student had enrolled in Algebra 1 anytime after 9th grade (i.e., 10th or 11th grade). The Algebra 1 enrollment variable was input into the appropriate models using the i.[var] command in Stata, which provided separate coefficient values per level, with “0” being the base group.

Latent moderator variables

Mathematics self-efficacy. Mathematics self-efficacy is a latent variable of students’ beliefs based on questions related to their mathematics courses. The composite variables Self-efficacy 1 (wave 1) and Self-efficacy 2 (wave 2) were used to measure students’ mathematics self-efficacy beliefs in the longitudinal models, namely students’ self beliefs about their 9th and 11th grade mathematics courses. These two measures are based on student responses to four identical items on the student questionnaire used in both waves of the HSLS study (Ingels et al, 2011; Ingels & Dalton, 2013). These measures were confirmed from the original study using Confirmatory Factor Analyses (CFA). The questions used for the self-efficacy measures focused on students’ beliefs about their ability to do well on their mathematics tests (s1mtests and s2mtests), understand their mathematics textbook (s1mtextbook and s2mtextbook), gain the skills need to pass their mathematics course (s1mskills and s2mskills), and their perceived ability to excel in their mathematics course (s1massexcl and s2massexcl). Each variable used to create the composite measures ranged from “1,” strongly disagree to “4,” strongly agree. Students were asked, for example, questions such as: “I am confident I can do excellent in my [fall 2009/spring 2012] math course.” The composite variables are continuous measures. A total of eight variables, four per wave, were subsequently created for the factors: Self-efficacy 1 (mathse11, mathse12, mathse13, mathse14) and

Self-efficacy 2 (mathse21, mathse22, mathse23, mathse24). Self-efficacy 1 had a range from -2.78 to 1.47 and Self-efficacy 2 had a range from -2.37 to 1.57, with higher values representing a higher mathematics self-efficacy. The Cronbach's Alpha coefficient was .90 and .89 for Self-efficacy 1 and Self-efficacy 2, respectively.

Mathematics identity. Mathematics identity is a latent variable of students' beliefs about their perception as being someone who can do mathematics and their perception of others' beliefs in the same regard. The composite variables Identity 1 (wave 1) and Identity 2 (wave 2) were created and used to measure mathematics identities. The composite variables Identity 1 (wave 1) and Identity 2 (wave 2) were used to measure student identities in all models. These two measures are based on student responses to two identical items on the student questionnaire used in both waves of HSLS (Ingels et al, 2011; Ingels & Dalton, 2013). These measures were confirmed using CFA. The questions used for these measures focused on whether students viewed themselves as a "math person" (s1mperson1 and s2mperson1) and their perception of whether others viewed them as a "math person" (s1mperson2 and s2mperson2). Each variable used to create the composite measures ranged from "1," strongly disagree to "4," strongly agree. Students were asked to answer the following two questions: "I see myself as a math person" and "Others see me as a math person." The two composite variables are continuous measures. A total of four variables, two per wave, were subsequently created for the factors: Identity 1 (mathid11, mathid12) and Identity 2 (mathid21, mathid22). Identity 1 had a range from -1.51 to 1.46 and Identity 2 had a range from -1.39 to 1.54, with higher values representing a stronger mathematical identity. The Cronbach's Alpha coefficient was .95 and .98 for Identity 1 and Identity 2, respectively.

Academic Peer Network *(Peer Network)*. Peer Network is a scale of a student's perception of their peers' academic orientation and content of peer communication. This scale was created using Principal Components Analysis (PCA) with the w1student weight. The Peer Network measure was created from ten variables that centered on the academic orientation of students' peers, namely whether or not a student perceived their closest friend: (1) to get good grades in school (s1frndgrades), (2) to be interested in school (s1frndschool), (3) to attend class regularly (s1frndclass), and (4) to have a desire to attend college (s1frndclg). These four items were grouped with six other items related to youth's perception of their communication with their peers; namely, (5) if students talked to their friends about mathematics courses (s1frndtalkm), (6) if students talked to their friends about science courses (s1frndtalks), (7) if students talked to their friends about other academic courses (s1frndtlkoth), (8) if students talk to their friends about college (s1frndtlkclg), (9) if students talked to their friends about future jobs/careers (s1frndtlkjob), and (10) if students talk to their friends about their problems (s1frndtlkprb). Response options for the first four items were "true" and "false." Response options for the last six items were "yes" and "no." The composite measure had a range from -3.44 to 3.23, with higher values representing a student's perception of a more academically oriented network of peers. The Cronbach's Alpha coefficient was .74 for the ten items.

Sense of School Belonging *(School Belonging)*. School Belonging is a scale of perception of school belonging. It was created by the original HSLS researchers using PCA (weighed by w1student) and standardized to have a mean of 0 and standard deviation of 1. The School Belonging scale was created from five variables: (1) whether a student felt safe in their school (s1safe), (2) whether a student was proud of their school (s1proud), (3) whether a student had an adult in the school that they could talk to about their problems (s1talkprob), (4) whether a student thought school was a waste of time (s1schwaste), and (5) whether a student felt getting good grades was important (s1goodgrades). Sample questions include: "I feel that school is a waste of time," and "Getting good grades is important in 9th grade." Response options for each item ranged from "1," strongly agree to "4," strongly disagree. The School Belonging scale had a range from -4.35 to 1.59. The Cronbach's Alpha coefficient was .65 for the five items (Ingels et al, 2011).

Sense of School Engagement *(School Engagement).* School Engagement is a scale of perception of engagement in classroom-based activities. This scale was created by the original HSLS researchers using PCA (weighed by w1student) and standardized to have a mean of 0 and a standard deviation of 1. The School Engagement scale was created from four variables: (1) how often a student showed up to class with no homework done (s1nohwdn), (2) how often a student came to class without pen or paper (s1nopaper), (3) how often a student came to class without the textbook (s1nobooks), and (4) how often a student was late to class (s1late). Sample questions include: "How often do you come to class without your homework done," and "How often do you come to class late." Response options for each item ranged from "1," strongly agree to "4," strongly disagree. The School Engagement scale had a range from -3.38 to 1.39. The Cronbach's Alpha coefficient was .65 for the four items (Ingels et al, 2011).

Mathematics Learning Environment *(Learning Environment)*. Learning Environment is a scale of students' perceptions of their 9th grade mathematics classrooms, specifically their experiences in their primary mathematics learning environments for the academic year in question. This scale was created using PCA and the w1student weight. The Learning Environment measure was created from nine variables that centered on a student's perception of their 9th grade mathematics teacher in various areas. These items measured whether the student perceived their mathematics teacher to be a person who: (1) valued and listened to student ideas (s1mtchvalues), (2) treated students with respect (s1mtchrespct), (3) treated every student fairly (s1mtchfair), (4) thought all students could be successful (s1mtchconf), (5) thought mistakes were okay if students learn (s1mtchmistke), (6) treated some students better than others (s1mtchtreat; *reverse coded*), (7) made math interesting (s1mtchintrst), (8) treated males and females differently (s1mtchmfdiff; *reverse coded*), and (9) made math easy to understand (s1mtcheasy). Response options ranged from "1" strongly agree to "4" strongly disagree. As noted, item six and item eight were reverse coded to ensure the variables were in alignment with all other items in the scale. The composite measure had a range from -8.26 to 3.44, with higher values representing students' perceptions of more positive mathematics classroom environments conducive to increasing student motivation and proficiency. The range noted in this composite measure was likely due to the fact that participants came from over 900 schools across the United States and thus the range and diversity that exists within schools account for this variation. In addition, the current study did not include hierarchical analyses which further contribute to the range noted for this factor. Nonetheless, the Cronbach's Alpha coefficient was .89 for the nine items.

Outcome variable

Algebraic Proficiency *(Proficiency)*. Proficiency was based on Item Response Theory (IRT) probability levels that were hierarchical in nature and indicated the likelihood, i.e., probability, of mastery in a specific Algebraic domain. Each level was created from clusters of items from the original HSLS mathematics assessment; each level contained item clusters representing common content and difficulty. The IRT values represented a student's score based on “a particular criterion set of test items” (Ingels et al., 2011, p. 13; Ingels & Dalton, 2013) from a 72-item assessment in mathematics based on various Algebraic skills. IRT models the patterns of correct, incorrect, and omitted answers to obtain comparable ability estimates and probabilities that can be summed to a statistical estimate of the number of correct items *expected* per student, particularly in instances when time constraints or circumstances prevented a student from completing an exam of such length. For example, if a student did not answer all 72 questions or was unable to complete the exam because of lack of time, IRT could be used and was in most cases. This IRT estimate was then used to produce a final score, the standardized theta score. The standardized theta score is a transformation of the IRT estimate; it was then rescaled to a mean of 50 and a standard deviation of 10. “An advantage of the standardized score over the IRT score is that it facilitates comparison in standard deviation units” (Ingels et al, 2011, p. 13). There were also a total of seven wave 2 Algebraic proficiency probability levels.

The individual levels and associated content for each level of proficiency were as follows: Level 1: Algebraic Expressions (x2txmprof1), Level 2: Multiplicative & Proportional Thinking (x2txmprof2), Level 3: Algebraic Equivalents (x2txmprof3), Level 4: Systems of Equations (x2txmprof4), Level 5: Linear Functions (x2txmprof5), Level 6:

Quadratic Functions (x2txmprof6), Level 7: Log and Exponential Functions (x2txmprof7). Each probability level represented the likelihood that a student would achieve proficiency in the specified mathematical domain and similar content. Furthermore, proficiency at lower levels was implied by mastery at higher levels. As is the general case with probabilities, each level ranged from 0 to 1, with the latter indicating absolute probability of content proficiency. For example, a value of .44 represented a 44 percent chance of achieving proficiency based on the IRT estimates. Based on the differences noted in Table 2 between black and non-black students, the Algebraic proficiency levels were included in the final analytic plan to determine if there were differences within the all black student sample based on variables such as sex and Year of Algebra 1 enrollment.

Table 2

Algebraic Proficiency Levels–HSLS: 2009, Wave 2

Mathematics Proficiency Level	**% Proficient in Knowledge and Skills by Proficiency Level (Wave 2)**		
	Black Students *N = 3,756*	Non-black Students *N = 19,125*	Difference
Level 1: Algebraic Expressions	87.2%	92.4%	-5.2
Level 2: Multiplicative & Proportional Thinking	61.5%	74.7%	-13.2
Level 3: Algebraic Equivalents	47.9%	63.9%	-16.0
Level 4: Systems of Equations	14.8%	28.6%	-13.8
Level 5: Linear Functions	8.3%	19.0%	-10.7
Level 6: Quadratic Functions	2.3%	5.3%	-3.0
Level 7: Log & Exponential Functions	0.9%	2.3%	-1.4

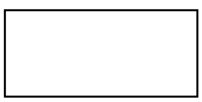
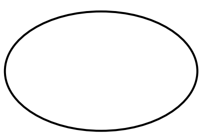
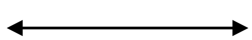
Estimates weighted by w2w1stu. SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. High School Longitudinal Study of 2009 (HSLS: 2009) Base-Year to First Follow-up Public-Use File (NCES 2014-358).

3.4 ANALYSIS

Data for this study was analyzed in Stata 13 using a series of *do* files. The outlined research questions were answered using the hypotheses and specific methods detailed in the upcoming sections. Specifically, I adopted the use of traditional SEM techniques provided by Kline (2010) to build and test measurement and structural models in the Stata 13 SEM Builder. Additionally, I made use of more traditional statistical techniques to produce descriptive results. Table 3 provides a description of the figures and terms utilized in the SEM techniques employed and table provided in the study.

Table 3

Structural Equation Model (SEM) symbols and their meanings

Symbol	Definition
	A rectangle represents an observed variable
	An ellipse represents a latent variable; latent variables are not observed and are constructed using a factor analysis method
	A single-headed arrow defines a regression path between variables
	A double-headed arrow represents a correlation or covariance between exogenous variables

(Arbuckle, 2007)

The following procedures were employed to generate analytic notes for the findings and discussion in chapters four and five: to answer the first research question, a Seemingly Unrelated Regression (SUR) model was constructed to measure the direct effect of all background and wave 1 measures on the wave 2 measures of mathematics self-efficacy, mathematics identity, and Algebraic proficiency. Basic tests for differences in means were conducted, specifically the Wilcoxon-Mann-Whitney test and two independent samples t-tests, on the mathematics identity and mathematics self-efficacy scales. Statistical models were constructed and tests were conducted with latent variables to answer the second research question. Algebraic proficiencies were assessed and analyzed to see if, on average, students' proficiencies differed by sex.

3.5 DELIMINATIONS

The following delimitations were noted in the outlined procedures. First, only students identifying as black in the HSLS documentation files were studied. Due the goals of the current study, these students were deemed essential to the overall analyses based on the literature provided in chapter two and my interests as a researcher. Alternatively, this study could have included students of all racial-ethnic backgrounds to answer the outlined research questions. Further, more than one group could have been used to examine whether or not the trends noted in the current population are standard across all racial-ethnic groups or specific to this one racial-ethnic group. Second, while the findings of the current study provided representative measures for black youth across the United States, the experiences of the original sample identified could vary largely based on a host of contributing factors. One key factor that could contribute to these differences is the type of institution that a student was enrolled in, such as private versus public or a more supportive versus a more marginalizing learning environment, for example. Given that this study was interested in the student experience and their assessment of their experiences, and due to the nature of available data, notes and options attended to the potential inaccuracies given the quantitative nature of the study. Further, this research study could have utilized two-level longitudinal analyses to see if the noted findings differed by nesting students in their schools and/or classrooms. However, given that the data used was public, there was incomplete or suppressed information in HSLS to run these analyses with the level of flexibility and assurance needed in SEM modeling.

CHAPTER FOUR

RESULTS OF THE STUDY

The results of the study are outlined in several sections. Descriptive results and correlation analyses are presented in the first section. The second section describes the results of the structural and measurement models for mathematics self-efficacy and mathematics identity. The third section is divided into two parts. The first part of section three provides a summary of the Seemingly Unrelated Regression (SUR) model constructed to measure the direct effects of all background and wave 1 measures on the wave 2 measures of mathematics self-efficacy, mathematics identity, and Algebraic proficiency. The second part of section three details the results of additional tests for sex differences. The fourth section describes the results of the latent variable models constructed to measure variations in direct and reciprocal effects of mathematics self-efficacy and identity measures. The fifth section notes any limitations.

4.1 DESCRIPTIVE ANALYSES

A summary of descriptive data for the study variables is provided in the following sections; the below analyses provide a description of these data with notes on variation, skewness, and kurtosis when deemed necessary to the interpretation of the results. The final participant sample for the study included 1,362 youth. As noted before, there were a total of 687 males (50.44%) and 675 females (49.56%) in the participant sample. Socioeconomic status (SES) had a mean of -0.24 and the standard deviation was .67, indicating a slightly narrow distribution of scores. With a skewness of .41 and kurtosis of

3.47, the SES measure reflected a Weibull distribution, which is a slightly positively skewed and flattened distribution toward lower socioeconomic status.

Year of Algebra 1 enrollment for the students ranged across grade levels, with the majority of students enrolling in Algebra 1 in their 9th grade year (n = 895, 65.71%). A total of 278 students (20.41%) enrolled in Algebra 1 during their 8th grade year and fewer students (n = 166, 12.19%) enrolled in Algebra 1 after their 9th grade year. Twenty-three students (1.69%) had not yet enrolled in Algebra 1 by their 11th grade year and, thus, were enrolled in either a pre-Algebra or "remedial" mathematics course at the time of data collection. The mean for Algebra 1 enrollment was 1.90 with a standard deviation of .59, which, as the percentage data shows below, groups most students as having taken Algebra 1 earlier during their high school coursework.

Table 4

Year of Algebra 1 Enrollment

Grade	***n***	**%**
8th	278	20.41%
9th	895	65.71%
After 9th	166	12.19%
Not yet Enrolled	23	1.69%
	1,362	100%

The Self-efficacy 1 (wave 1) variable had a mean of .18 and the standard deviation of .86 reflects a moderate to standard distribution of scores. The self-efficacy 2 (wave 2) variable had a mean of .17; similarly, the standard deviation of .86 for this variable reflects a moderate to standard distribution of scale scores. Generally, students' self-efficacy beliefs increased from grade 9 to grade 11, although the averages do not indicate so on immediate inspection. A dichotomous variable, mathse_d, created for the wave 1 measure of mathematics self-efficacy with “0” coded as ‘below sample average’ and “1” coded as ‘above sample average’ had a mean of .67 and a standard deviation of .47, indicating that 67% of the participants had a self-efficacy scale score above the mean.

The identity 1 (wave 1) variable had a mean of .04 and the standard deviation of .84, similar to the self-efficacy scores, reflected a moderate to standard distribution of scores. The Identity 2 (wave 2) variable had a mean of 0 and a standard deviation of .90, which reflects a standard distribution of scores. A dichotomous variable, mathid_d, created for the wave 1 measure of mathematics identity with “0” coded as ‘below sample average’ and “1” coded as ‘above sample average’ had a mean of .47 and a standard deviation of .49, indicating that 47% of the participants had a scale score above the mean for Identity 1.

The Peer Network scale had a mean of -0.20 with a standard deviation of 1.65, indicating a slightly wider variation in scores but given the large negative range of the scale this was not viewed as concerning. The School Belonging scale had a mean of .06 with a standard deviation of .98, indicating a standard distribution of scores. The School Engagement Scale had a mean of .01 with a standard deviation of .98, reflecting, similar to School Belonging, a standard distribution of scores. The Learning Environment scale had a mean of .23 and a standard deviation of 2.27, indicating a wider distribution of scores. The skewness of the Learning Environment scale was -0.59 and the kurtosis was 3.40, indicating a double exponential distribution with a stronger peak and heavier positive valued tail. Namely, students were more polarized toward the positive tail end of the distribution, indicating more positively perceived learning environments on average. Sex differences contributing to this assessment are discussed later.

The IRT measure of mathematics score, which was used to determine the various proficiency levels, had a mean of 48.34 and a standard deviation of 8.64. The scores ranged from 27.26 to 79.89, with higher scores representing more correct items based on an evaluation of peer estimates from the original HSLS sample. The 25th percentile score was 40.01, the 75th percentile score was 51.93, and the 99th percentile score was 64.89, helping to further indicate a more slightly non-normal distribution, with a sudden flatness in the distribution around higher scores for the study participants. This trend was also noted in the original full sample as well. This finding is likely due to the variation of course enrollments and, on average, the lower achievement of American youth in more advanced mathematics courses.

The mean values for the Algebraic proficiency levels equate to probability percentages for the sample, and the standard deviation values indicate the distribution of proficiency likelihoods across the study sample. The probability levels for the entire sample are provided in Table 2. Level 1, Algebraic Expressions, had a mean of .90 and a standard deviation of .21, indicating that, on average, study participants had a 90% probability of proficiency at the lowest of the proficiency levels in their 11th grade year (wave 2). Level 2, Multiplicative & Proportional Thinking, had a mean of .69 and a standard deviation of .35, indicating that, on average, participants had a 69% chance of proficiency in this content level with a slightly higher distribution of probability scores across the sample than Level 1. Level 3, Algebraic Equivalents, had a mean of .53 and a standard deviation of .37, following in line with a lower probability of proficiency as the levels increase and a slightly higher distribution of scores. Level 4, Systems of Equation, had a mean of .17 and a standard deviation of .24, indicating a significant drop in participants' likelihood of proficiency in this content domain; namely, on average, participants were 17% likely to be fully proficient in systems of equations and similar content (e.g., Algebra 2). Level 5, Linear Functions, had a mean of .10 and a standard deviation of .18, indicating less variation in the distribution of proficiency probabilities toward a lower likelihood of 10%. Levels 6 (Quadratic Functions) and 7 (Log and Exponential Functions) had means (and standard deviations) of .02 (.03) and .01 (.02), respectively, both indicating an almost zero percent probability of full proficiency, on average, across the sample. The interpretation of these values should be done with caution given variations of what one may deem as 'proficient'; in general, for this study, proficiency was determined based on the IRT measure for a student's likelihood to show mastery in a given content domain and proficiency level.

Correlation Analyses

Pearson correlation coefficients were utilized to examine significant relationships among the study's variables. A significant positive relationship was found between sex and Identity 1 (r = .12, p < .01). Given that the same relationship was not found between sex and Identity 2, this finding reveals that females' identity reduced by their 11th grade year and was lower than males'. A significant relationship was found between sex and Peer Network (r = .15, p < .01), indicating that females were more likely to have or report a more academically oriented perception of their peer networks. A significant relationship was also found between sex and Learning Environment (r = .12, p < .01) indicating that female students were more likely to perceive their mathematics classroom learning environments as more conducive to motivation and learning; this finding connected to skewness of the Learning Environment scale. Significant positive relationships were found between sex and School Engagement ($r = .17$, $p < .01$) and sex and School Belonging ($r = .08$, $p < .01$), indicating that female students were more likely to report being more engaged in school and more likely to feel as if they were a member of their school environments. A significant relationship was also found between sex and mathematics score ($r = .08$, $p < .01$); although negligible in scope, this value points to potential nuances in sex differences for mathematics proficiency. Further analyses in this particular area are provided in section 4.5.

A statistically significant negative correlation was found between socioeconomic status and year of Algebra 1 enrollment ($r = -0.16$, $p < .01$), indicating that students of lower socioeconomic backgrounds were more likely to enroll in Algebra 1 in later academic years. A significant positive relation was found between socioeconomic status and Peer Network ($r = .16$, $p < .01$) indicating that students of higher socioeconomic status were more likely to report more academically oriented peer networks. A strong significant relationship was also found between socioeconomic status and mathematics score ($r = .28$, $p < .01$), indicating that student proficiency scores were more likely to increase with socioeconomic status. This finding can be likely attributed to the resources and environments that are often germane to schools with higher socioeconomic student populations.

A statistically significant negative correlation was found between year of Algebra 1 enrollment and Identity 1 ($r = -0.12$, $p < .01$); this finding indicated that students who enrolled in Algebra 1 later during their high school careers were more likely to have less positive mathematics identities. A similar association was found between year of Algebra 1 enrollment and Identity 2 ($r = -0.10$, $p < .01$). Similarly significant but seemingly negligible associations were also found between year of Algebra 1 enrollment and each of Self-efficacy 1 ($r = -0.08$, $p < .01$) and Self-efficacy 2 ($r = -0.07$, $p < .01$). As is the case with mathematics identity, these associations signify that students who enroll in Algebra 1 later during high school were more likely to feel less confident about their mathematical skills and abilities.

A strong significant positive relationship was found between Self-efficacy 1 and Self-efficacy 2 ($r = .29$, $p < .01$). A stronger positive relationship was found between Self-efficacy 1 and each of Identity 1 ($r = .53$, $p < .01$) and Identity 2 ($r = .31$, $p < .01$). Similarly, Self-efficacy 2 was significantly related to Identity 1 ($r = .22$, $p < .01$) as well as Identity 2 ($r = .52$, $p < .01$). These findings are of extreme importance and indicate that students' identities and self-efficacy beliefs, given the focus of the current study, are co-constructed and depend largely upon one another in a longitudinal manner, with a note of the general statistical rule that correlation does not imply causation. Moreover, the Pearson correlation values attached to the linked variables contribute to the hypothesis that the factors are reciprocally related. This assessment was made given the strength of the correlation values.

Peer Network was significantly related to the wave 1 scales of self-efficacy and identity. Namely, Peer Network had a significant relationship with Self-efficacy 1 ($r = .11$, $p < .01$) as well as Identity 1 ($r = .12$, $p < .01$). This finding indicates that students who perceived their peer network to be more academically oriented held higher beliefs about their mathematical abilities and were more likely to see themselves as a "math person." Interestingly, however, Peer Network was not significantly related to the wave 2 versions of the self-efficacy or identity scales, which possibly indicates that students may be making decisions utilizing additional factors or components and not be making decisions about things based solely on their peers. Peer Network was also significantly, albeit marginally, related to School Engagement ($r = .07, p < .05$) and strongly related to School Belonging ($r = .17, p < .01$). These findings indicate that students with more academically oriented perceptions of their peer networks were more likely to have a stronger sense of school belonging and report stronger measures of engagement. Peer Network also had a positive relationship with mathematics score ($r = .20, p < .01$), indicating that students with more academically oriented perceptions of their peer networks were more likely to have higher mathematics proficiency outcomes.

As expected, Learning Environment was strongly related to School Belonging ($r = .40, p < .01$) and School Engagement ($r = .18, p < .01$), although less related to engagement by more than .20. This finding indicates that students who perceived their mathematics learning environments to be conducive to their motivation and learning were more likely to report a much higher sense of school belonging, in addition to a significant connection to their engagement. School Belonging and School Engagement were significantly related as well ($r = .19, p < .01$), indicating that as a student's sense of belongingness increased so did their likelihood of being engaged in school. School Belonging was also significantly related to mathematics score ($r = .09, p < .01$). This finding indicated that a higher sense of belonging was more likely to result in higher Algebraic proficiency outcomes for students. These findings supported the need to understand the structure and measurement of the factors in singular models.

4.2 STRUCTURAL AND MEASUREMENT MODELS

Structural Equation Modeling, Factor Analysis, and Latent Variable Modeling are primarily concerned with parsimony; namely, describing relationships between observed (or manifest) and latent variables as simply as possible (Kline, 2010). Manifest variables are observed measures directly gathered during data collection. Latent variables are theorized variables, such as Identity 1 or Self-efficacy 2, which utilize a larger number of observed variables and simplify their relationship into one indicator variable. In the models used for this study, relationships between the latent variables were analyzed over the two waves of the study to examine the nature of individual self-efficacy beliefs and identity in mathematics.

Given their centrality to the study, factor analysis and latent variable modeling were performed to assess the structures of Identity 1 (wave 1), Self-efficacy 1 (wave 1), Identity 2 (wave 2), and Self-efficacy 2 (wave 2). Ingels et al (2011) utilized an identical factor structure when generating scales used in the original HSLS dataset, which confirmed and distinguished the two factors. However, it was necessary to re-confirm the structure of these factors and test their reliability with the current study population, largely based on variations in the literature presented in chapter 2, before assessing the latent variable models.

Factor Analysis

Confirmatory Factory Analysis (CFA) methods were used to identify and generate the identity and self-efficacy measures. The CFA models identified in this study for the self-efficacy and identity constructs were developed from a total 12 observed variables.

There were a total of two per wave for mathematics identity (mathid11, mathid12, mathid21, mathid22). There were a total of four per wave for mathematics self-efficacy (mathse11, mathse12, mathse13, mathse14, mathse21, mathse22, mathse23, mathse24).

Using rotated factor loadings, the scales with only those loadings of a value greater than .50 for any factor were retained. This allowed for the confirmation of the factors to include values for which the factors were originally measured; namely, the factors were confirmed and held for the sample in this study. Table 5 provides the factor loadings for each of the items in the self-efficacy and identity scales used in all analyses; the factor loadings represent both how the variables are weighted for each factor and the correlation between the variables and the given factor.

Table 5

Confirmatory factor loadings for mathematics identity and mathematics self-efficacy factors

Variable	**Item**	**Factor Loading** MID w1	MID w2	MSE w1	MSE w2
mathid11	I am a math person (grade 9)	.5676			
mathid12	Others see me as a math person (grade 9)	.8908			
mathid21	I am a math person (grade 11)		.9321		
mathid22	Others see me as a math person (grade 11)		.6399		
mathse11	I can do excellent on math tests (grade 9)			.8221	
mathse12	I can understand my math textbook (grade 9)			.7176	
mathse13	I can master math skills (grade 9)			.7827	
mathse14	I can do excellent on math assignments (grade 9)			.7822	
mathse21	I can do excellent on math tests (grade 11)				.8406
mathse22	I can understand my math textbook (grade 11)				.6244
mathse23	I can master math skills (grade 11)				.7883
mathse24	I can do excellent on math assignments (grade 11)				.7899

Note: Only factor loadings greater than .50 included

A factor rotation matrix and correlation analyses between the factors were run and analyzed to examine how each constituted factor was weighted based on the variables. Table 6 provides the correlation of the factors detailed in Table 5; this table provides information on the correlation among the factors after an oblique rotation, which provided both the pattern and structure matrices. This procedure was conducted using the *rotate* and *estat* commands in Stata after the items were loaded into the factor model.

Table 6

Factor correlation matrix

	MIDw1	MIDw2	MSEw1	MSEw2
MIDw1	1			
MIDw2	.5033	1		
MSEw1	.5298	.3781	1	
MSEw2	.2495	.4959	.2979	1

The latent variable models for mathematics identity and mathematics self-efficacy were assessed using model fit statistics. Chi-squared is the most common and widely used model fit index. The chi-squared index is derived directly from an analysis of the implied and observed covariance matrices and small significant *p* values are considered less desirable, as it determines whether one should reject the null hypothesis. Ideally, higher *p* values, for example those above .30, are considered appropriate. However, chi-squared fit statistics commonly 'fail' with studies using larger sample sizes and thus were interpreted with caution in this study (Kline, 2010). The RMSEA (Root mean squared error of approximation) examines discrepancies between observed and predicted covariance structures and values at or below 0.10 are generally considered adequate. The CFI (Comparative Fit Index) compares the hypothesized model to a baseline model and assumes zero correlation between all variables, in general values above 0.90 considered adequate for this index. The SRMR (Standardized root mean squared residual) provides the mean absolute value of the covariance residuals and higher numbers indicate a less than desired fit and values less than 0.10 are considered adequate. AGFI (Adjusted Goodness of Fit Index) was not used because it is known to not perform well in simulation studies, as noted by Kline (2010). Maximum likelihood estimations were used to fit all models.

Between-Factor Measurement Model Results

Figure 3 provides the measurement model results for the CFA model between Identity 1 and Self-efficacy 1. There was a significant correlation (r = .33) between the Identity 1 and Self-efficacy 1 factors in the measurement model. Generally, CFA factors correlated at this stage would have the expectation of providing independence with a non-significant correlation; however, this finding provides evidence that the two factors are indeed differentiable and strongly related. The chi-squared value for the overall model was significant, $X^2(8) = 37.89$, $p < .001$, suggesting a lack of fit between the model and the data. However, Kline (2010) discussed the sensitivity of X^2 in large samples that generally exceed 200 cases, so additional fit indices were assessed. An analysis of additional fit indices for the wave 1 factors showed acceptable model fit by general structural modeling standards with RMSEA = 0.05, CFI = 0.99, and SRMR = 0.01.
In Figure 4, the results for the CFA measurement model associating Identity (T2) and Self-efficacy (T2). There was a significant correlation (r = .36) between the Identity (T2) and Self-efficacy 2 factors in the measurement model; again, as was the case with the previous model, this finding supported the factors' co-construction and interdependence

in wave 2. Chi-squared value for the overall model fit was significant, $X^2(8) = 59.43$, $p < .001$, suggesting a lack of fit between the model and the data. However, again, as suggested by Kline (2010), the sensitivity of X^2 in large samples deemed additional fit indices to be utilized in assessing this model. Fit indices for the wave 2 CFA showed acceptable model fit with RMSEA = 0.07, CFI = 0.98, and SRMR = 0.03. Based on these results and acceptable factor models, regression and latent variable structural equation modeling was performed to connect the factors in a longitudinal relationship within and between wave 1 and 2 data.

4.3 REGRESSION MODELS AND ADDITONAL TESTS

Seemingly Unrelated Regression (SUR) Model

SUR models generally contain multiple regression models in one model. One important distinguishing feature of SUR models from other regression analyses is that the error terms are allowed to correlate with one another, which made this type of analysis useful under the SEM framework used in this study (Kline, 2010). On initial inspection, the equations in a SUR seem unrelated but are connected by the correlations in their error terms; this is a theoretically defined relationship. To analyze the SUR model, I used Stata's *sureg* command, which computes estimates based on Zellner's SUR, and predicted the following wave 2 factors: Identity (T2), Self-efficacy (T2), and the IRT estimate of Algebra proficiency. These were regressed using the background and wave 1 factors of sex, socioeconomic status, year of Algebra 1 enrollment, Identity 1, Self-efficacy 1, Peer Network, School Belonging, School Engagement, and Learning Environment. As a result, I was able to estimate their cross-year effects. Interaction terms were not used in the SUR models due to the method's measurement properties.

Model one, noted in equation (1), provides the first of three models fit using SUR. To understand how grade 9 factors affected a measure of students' knowledge in 11^{th} grade Algebraic proficiency was used. The model included sex, SES, Year of Algebra 1 enrollment, mathematics identity, mathematics self-efficacy, peer network, school belonging, school engagement, and school environment. Each regression line pointing toward the outcome variable, i.e., Algebraic proficiency generated an error term, which was allowed to correlate with other error terms in the model.

Model two, noted in equation (2), provides the second of three models fit, specifically to understand how grade 9 factors affected students' mathematics identity in 11^{th} grade. The model included sex, SES, Year of Algebra 1 enrollment, mathematics self-efficacy, peer network, school belonging, school engagement, and school environment. This model did not include 9^{th} grade mathematics identity to avoid overestimation.

Model three, noted in equation (3), provides the third of three models fit, specifically to understand how grade 9 factors affected students' mathematics self-efficacy. The model included sex, SES, Year of Algebra 1 enrollment, mathematics identity, peer network, school belonging, school engagement, and school environment. This model did not include 9^{th} grade mathematics self-efficacy to avoid overestimation.

Based on the hypotheses presented in Chapter 2, the following SUR models were fit for the study:

(1) $$Algebraic\ Proficiency = \alpha + \beta_1 Gender + \beta_2 SES + \beta_3 YearAlgebra\ 1 + \beta_4 MID_{w1} + \beta_5 MSE_{w1} + \beta_6 PeerNetwork + \beta_7 SchoolBelonging + \beta_8 SchoolEngagement + \beta_9 LearningEnvironment + \varepsilon_i$$

(2) $Mathematis\ Identity_{w2} = \alpha + \beta_1 Gender + \beta_2 SES + \beta_3 YearAlgebra\ 1 + \beta_4 MSE_{w1} + \beta_5 PeerNetwork + \beta_6 SchoolBelonging + \beta_7 SchoolEngagement + \beta_8 LearningEnvironment + \varepsilon_i$

(3) $Mathematics\ Self\ efficacy_{w2} = \alpha + \beta_1 Gender + \beta_2 SES + \beta_3 YearAlgebra\ 1 + \beta_4 MID_{w1} + \beta_5 PeerNetwork + \beta_6 SchoolBelonging + \beta_7 SchoolEngagement + \beta_8 LearningEnvironemnt + \varepsilon_i$

Equation (1) assessed the effects of wave 1 external factors on the wave 2 factor of algebraic proficiency. Specifically, it measured direct effects of sex, socioeconomic status, year of algebra 1 enrollment, 9th grade mathematics identity, 9th grade mathematics self-efficacy, students perceptions of their peer network in 9th grade, school belonging, school engagement, and perceptions of their mathematics classroom environment on a measure of proficiency used to examine differences in achievement outcomes.

Equations (2) and (3) utilized these same factors but examined their direct effects on mathematics identity and mathematics self-efficacy, respectively. Namely, the second and third models provided a more focused understanding of how these factors help to inform, and further structure, the relationship between mathematics identity and mathematics self-efficacy. Altogether, this model provided the information necessary to analyze longitudinal effects of wave 1 factors on wave 2 factors presented in this study. Given the between-factor latent variables, Identity 1 and Self-efficacy 1 were not included in the SUR models in which their wave 2 constructs were being fit, i.e., equations (2) and (3) did not contain their own wave 1 measures of mathematics identity and mathematics self-efficacy, respectively.

Unstandardized regression coefficients are provided with *p*-values in the following paragraphs. Table 7 provides coefficients for the Seemingly Unrelated Regression (SUR) model presented in this section. Standardized coefficients, when using Stata's *beta* option, were not available when conducting SUR analyses due to the correlated errors across factors. Resultantly, the Root Mean Square Errors (RMSE), which measures the spread of the data around the regression line, is provided with the model statistics.

Table 7

Seemingly Unrelated Regression Model

Variable	Algebraic Proficiency	Mathematics Identity (Wave 2)	Mathematics Self-Efficacy (Wave 2)
Female	.94 (.480)*	-0.06 (.056)	-0.12 (.054)*
SES	2.47 (.347)***	-0. 06 (.040)	-0.15 (.039)***
Took Algebra 1 in 8th	10.26 (2.20)***	.30 (.255)	-0.25 (.249)
Took Algebra 1 in 9th	6.00 (2.161)**	.09 (.251)	-0.43 (.245)
Took Algebra 1 after 9th	1.91 (2.242)	.17 (.260)	-0.39 (.253)
MIDw1	.79 (.319)**	-	-0.12 (.030)
MSEw1	.47 (.311)	.17 (.030)***	-
Peer Network	.55 (.142)***	.01 (.016)	-0.01 (.016)
School Belonging	-0.06 (.256)	.07 (.029)*	.08 (.029)**
School Engagement	-0.31 (2.45)	.07 (.028)*	.07 (.028)**
Learning Environment	.00 (.112)	-0.01 (.011)	0.05 (.012)***
Constant	41.53 (2.15)***	-0.09 (.250)	.62 (.243)**
R^2	.22	.10	.06
RMSE	7.157	.833	.826
X^2	257.74***	86.63***	73.08***

*N = 1,362; * p<.05, ** p<.01, ***p<.001*

Algebraic proficiency was significantly predicted by a number of key variables. The model explained a significant proportion of variance in Algebraic proficiency, R^2 = .22, RMSE = 7.16, $X^2(10) = 257.74$, $p < .001$. Additionally, there was a constant of 41.53

(p < .001) for the sample. Sex significantly predicted Algebraic proficiency with females predicted to score higher than males, .94, $p < .05$. Socioeconomic status significantly predicted proficiency, with a nearly two and a half increase in proficiency for every unit increase in SES (2.47, $p < .001$). Year of Algebra 1 enrollment predicted Algebraic proficiency for students who enrolled in Algebra 1 in grade 8 (10.26, $p < .001$) and in grade 9 (6.00, $p < .01$). Freshman year mathematics identity (Identity 1) also significantly predicted proficiency, .79, $p < .01$. Contrastingly, mathematics self-efficacy (Self-efficacy 1) in the freshman year did not significantly predict proficiency in grade 11. Students' peer networks were the only other external factor to significantly predict proficiency (.55, $p < .001$). These findings suggested that Algebraic proficiency is likely informed by background and external factors, such as year of Algebra 1 enrollment and peers, as opposed to students' perceptions of their learning environment or their levels of school belongingness and school engagement. Based on the results of the structural models presented in the following section, these insignificant factors likely play a mediating role in affecting students' Algebraic proficiency. The results of the SUR model analyses for mathematics identity and mathematics self-efficacy help to provide further evidence to support these claims.

The T2 mathematics identity model explained a significant proportion of variance, $R^2 = .10$, RMSE = .833, $X^2(9) = 86.63$, $p < .001$. Sex was not a significant predictor of mathematics identity in the model nor was socioeconomic status. Additionally, year of Algebra 1 enrollment, peer network, and learning environment were not significantly predictors of mathematics identity. These results suggest that students' beliefs about themselves rest largely independent of these factors and that no general trends across the population existed. This was a little surprising given the predictive power of identity in the structural models and the significance of the correlation analyses between the identified factors. However, it did make sense given that the SUR models allow errors to correlate and there were no significant Pearson correlations with identity and proficiency in the descriptive analyses. Mathematics self-efficacy did significantly predict mathematics identity (.17, $p < .001$), indicating that students' early high school beliefs about their skills and abilities inform their beliefs about whether or not they see themselves as a math person and if they perceive that others see them as a math person.

Mathematics self-efficacy (Self-efficacy 2) was predicted by a number of variables included in the SUR model as well. The model explained a significant proportion of variance in students' mathematics self-efficacy beliefs, $R^2 = .06$, RMSE = .825, $X^2(9) = 73.08$, $p < .001$. Sex significantly predicted mathematics self-efficacy with males predicted, although marginally, to have higher self-efficacy beliefs (-0.12, $p < .05$). Socioeconomic status was a significant predictor of mathematics self-efficacy (-0.15, $p < .001$). Year of Algebra 1 enrollment did not significantly predict mathematics self-efficacy beliefs, indicating, as expected, that students' beliefs are independent of their specific year of Algebra 1 enrollment and were expected to be developed and not dependent on any particular mathematics course. School belonging, school engagement, and mathematics learning environment significantly predicted mathematics self-efficacy. The significance of school belonging (.08, $p < .01$) indicated that students' sense of belonging had an effect on their beliefs about their ability to succeed in specific mathematical contexts. Similarly, the significance of school engagement (.07, $p < .001$) suggested that the more a student is engaged in school the more likely the student is to have more stable beliefs in their mathematical skills and abilities. Lastly, and arguably one of the more important findings for the study, was the mathematics learning environment's significance (.05, $p < .001$). This finding confirmed that perceptions of mathematics learning environments as both a motivating and conducive space to mathematics learning significantly predicted mathematics self-efficacy. This was strongly suggested by the literature and was one of the central hypotheses of the current study.

Additional tests for sex differences

Wilcoxon-Mann-Whitney tests and two independent sample t-tests were conducted to assess sex differences for the variables included in the SUR model presented in the previous section. The Wilcoxon-Mann-Whitney (WMW) test was used when there was a non-normal distribution of the dependent variable. Normal distribution is a basic assumption of the two independent samples t-test. Normality was determined using probability-probability (P-P), or normal probability, plots and tests for skewness and kurtosis using Stata's *qnorm* and *sktest* functions. The tests were conducted on each of the following variables: Identity 1, Identity 2, Self-efficacy 1, Self-efficacy 2, Algebraic Proficiency, Peer Network, School Belonging, School Engagement and Learning Environment. Given that the former analyses were run using latent variable models the tests run for sex differences provided a focused analysis without the 'noise' of other statistical calculations and did not include correlates between variable errors.

T-tests were used for mathematics identity at both waves. There was no significant sex difference in 9th grade mathematics identity for males ($M = .05$, $SD = .85$) and females ($M = .04$, $SD = .03$), $t(1360) = 0.23$, $p = .8156$. There was, however, a significant sex difference in 11th grade mathematics identity for males ($M = .07$, $SD =$

.84) and females (*M* = -0.06, *SD* = .03), *t*(1360) = 2.77, *p* = .01, indicating that over time females developed more negative mathematical identities than males on average or, alternately, that males' beliefs increased in such a manner that a significant difference was maintained.

WMW tests were used for mathematics self-efficacy at both waves. The results suggested that there was a statistically significant difference between the distributions of self-efficacy beliefs in 9th grade between males and females (*z* = 3.034, *p* = .0024). The rank sum scores for males (463,774.5) were significantly higher than the rank sum score for females (414,700.5), indicating that males held higher mathematics self-efficacy beliefs in the 9th grade. The 11th grade mathematics self-efficacy results also suggested a significant difference between males and females (*z* = 3.298, *p* = .0010). The rank sum scores for males (460,454) were higher than the rank sum scores for females (406,132), indicating, similarly to 9th grade mathematics self-efficacy, that males maintained higher mathematics self-efficacy beliefs in the 11th grade.

T-tests were used for the IRT estimate of Algebraic proficiency at wave 2 and the linked Algebraic proficiency levels. There was no significant sex difference in Algebraic proficiency for males (*M* = 47.96, *SD* = 8.88) and females (*M* = 48.73, *SD* = 8.38), *t*(1360) = -1.650, *p* = .09. Of the seven Algebraic proficiency domains, there were significant differences by sex at Level 2 (Multiplicative & Proportional Thinking), with females' likelihood for proficiency (*M* = .74, *SD* = .33) greater than males' likelihood for proficiency (*M* = .70, *SD* = .34), *t*(1360) = -1.94, *p* = .05), and Level 3 (Algebraic Equivalents), with females' likelihood for proficiency (*M* = .62, *SD* = .37) greater than males' likelihood for proficiency (*M* = .58, *SD* = .37), *t*(1360) = -2.04, *p* = .04. No significant differences for the other Algebraic proficiency levels were found. This finding indicated the following: that males and females do not have significant differences in their Algebraic proficiency overall. However, in 'Multiplicative & Proportional Thinking' and 'Algebraic Equivalents' sex differences existed in students' likelihood of obtaining proficiency. In general, females' assessment of their abilities were significantly lower than males' assessments but their performance in key areas were the same or significantly greater than males, specifically as the levels began to increase, although for the majority of these levels there were no significant differences noted.

The WMW test was used to assess students' peer networks. The results suggested that there was a statistically significant sex difference between the distributions of students' peer networks (z = -4.037, p = .0001). The rank sum scores for males (325555) was significantly lower than the rank sum score for females (387860), indicating that males have a less academically oriented perception of their peers than females.

The WMW test for sex differences in students' sense of school belonging was not significant (z = .523, p = .6011), indicating that students' sense of school belonging was not dependent on their sex and, potentially, could be due to interaction with other variables that were beyond the scope of this study. However, the WMW test for sex differences in school engagement was statistically significant (z = -6.856, p = .0000). The rank sum score for males (383942) was substantially lower than females (478699), indicating that female students were more engaged in school than males. Interestingly, and in contrast to the notes provided in the modeling analyses, there were no significant sex differences in the WMW test for mathematics learning environment (z = -0.916, p = .3597), indicating that, on average, males and females perceived their mathematics learning environments similarly, although the rank sum scores for females is higher it is not statistically significant.

4.4 LONGITUDINAL LATENT VARIABLE MODELS

Each of the models assessed were hybrid models for longitudinal data as described by Kline (2010); the results of these models are provided in the Appendix. Similar to the models outlined by Kline (2010), the models included in this study had error term correlations between each wave 1 and wave 2 observed variables; these correlations are “a relatively common feature of hybrid models for longitudinal data [and] reflects the hypothesis that the measurement errors of repeated measures variables covary” (p. 258). “The 1.0s in the figure[s] represent fixed factor loadings that scale the latent variables” (Kline, 2010, p. 258). Additionally, the hybrid models assessed assumed that each of the wave 2 factors was caused by their own wave 1 counterpart. The three models assessed had these base features. In addition to the base features noted, each model had a slight variation in determining the co-constructive nature of the self-efficacy and identity constructs.

Model 1 (*Reciprocal Effects Model*), the well-fit model for the sample of students, assumed that the identity and self-efficacy factors at wave 2 reciprocally affected each other. Model 2 (*Internal Reciprocal Effects Model*) assumed, in addition to the factors at wave 2 reciprocally affecting one other, that there was an *internal* direct relationship between the Identity 1 and Self-efficacy 2 factors, as well as the Self-efficacy 1 and Identity 2 factors. Namely, Model 2 examined the wave 1 factors’ impacts on the wave 2 versions of themselves and the other factor. Model 3 (*Internal Effects Model*) did not assume the reciprocal relationship between the wave 2 factors but contained the *internal* direct relationship between the factors as described in Model 2. Due the results of the confirmatory factor analyses and the size of the participant sample, chi-squared fit statistics were computed but were deemed insufficient for the analyses. Alternatively, the AIC (Akaike's information criterion) and BIC (Bayesian information criterion) were computed and are reported, in addition to the other previously noted fit indices, to compare the three models for goodness of fit with the participant data. AIC is regarded as an information theory goodness of fit statistic that is used to compare models, with lower AIC values being optimal across model options. BIC is similar to AIC in that it provides a goodness of fit statistic using the log of the Bayesian factor target model to that of a saturated model; however, AIC is usually used in conjunction with BIC as more complex models, or models with smaller samples sizes, are significantly penalized for fit with the BIC fit statistic. A priori specification of alternative models were utilized based on evidence provided in Kline (2010) and other SEM texts; additionally, these models fit in line with the literature and *Mathematics Identity-Efficacy Connection* presented in chapter two.

Table 8

Parameter Estimates for the Reciprocal Effects Model (REM) of the Longitudinal Relation between Mathematics Self-Efficacy and Mathematics Identity

Parameter	Wave 1	Wave 2	Wave 1 to Wave 2
<u>Exogenous factor variances and covariance</u>			
Self-efficacy	.37**	-	-
Identity	.72**	-	-
Self-efficacy ⇔ Identity	.33** (.02)	-	-
<u>Disturbance variances and covariance</u>			
$D_{self\text{-}efficacy}$	-	.31** (.02)	-
$D_{identity}$	-	.46** (.09)	-
$D_{self\text{-}efficacy \Leftrightarrow identity}$	-	.06 (.09)	-
<u>Measurement error variances and covariances[b]</u>			
$E_{mathsei1}$ (I can do excellent on math tests)	.15** (.01)	.15** (.01)	.00 (.01)
$E_{mathsei2}$ (I can understand math textbook)	.28** (.01)	.39** (.02)	.02 (.01)
$E_{mathsei3}$ (I can master math skills)	.17** (.01)	.19** (.01)	.01** (.01)
$E_{mathsei4}$ (I can do excellent on math assignments)	.14** (.01)	.17** (.01)	.01 (.01)
$E_{mathidi1}$ (I am a math person)	.16** (.02)	.18** (.02)	.04** (.01)
$E_{mathidi2}$ (Others see me as a math person)	.29** (.02)	.21** (.02)	.02* (.01)
<u>Factor loadings</u>			
Self-efficacy → I can do excellent on math tests	1.00[nt] (.02)	1.00[nt] (.02)	-
Self-efficacy → I can understand math textbook	.99** (.03)	.88** (.03)	-
Self-efficacy → I can master math skills	.91** (.03)	.88** (.03)	-
Self-efficacy → I can do excellent on math assignments	.87** (.03)	.86** (.03)	-
Identity → I am a math person	1.00[nt] (.03)	1.00[nt] (.03)	-
Identity → Others see me as a math person	.84** (.03)	.88** (.03)	-
<u>Direct effects</u>			
Self-efficacy 1 → Self-efficacy 2	-	-	.19** (.04)
Identity 1 → Identity 2	-	-	.62** (.08)
Self-efficacy 2 → Identity 2	-	.16 (.28)	-
Identity 2 → Self-efficacy 2	-	.23** (.05)	-

Note. D, disturbance; E, measurement error; [a]Unstandardized (standardized). The standardized values for the disturbance and measurement error variances are proportions of unexplained variance; [b]The entries in the third column are the covariances; [nt]Not tested for significance because this loading is fixed to 1.0 to a scale factor; * $p < .05$, ** $p < .01$

Model 1: Reciprocal Effects between Identity and Self-Efficacy Model

Table 8 (above) and Table 10 (located in the Appendix) provide a detailed evaluation of the longitudinal relationships between the mathematics self-efficacy and mathematics identity constructs. Table 8 provides the parameter estimates for the model of the longitudinal relationship between the factors. Table 10 includes the Goodness of fit summary for the *Reciprocal Effects Model* (REM) in addition to the correlational statistics for each factor included in the model; further details for the REM are provided in the forthcoming paragraphs.

Figure 5 (Appendix) provides a visual of all measurement statistics for the Reciprocal Effects Model (REM). The analyses of the links between mathematics self-efficacy and mathematics identity within and across waves 1 and 2 were partially supported by the REM: $X^2(42) = 118.19$, $p < .001$; RMSEA = 0.03, CFI = 0.99, and SRMR = 0.02, AIC = 27656.47, BIC = 27902.98. The distinguishing feature of the REM, the reciprocal link between Self-efficacy 2 and Identity 2, showed a partially statistically significant reciprocal relationship between the two factors. Identity 2 had a significant reciprocal effect on Self-efficacy 2 (.23). However, Self-efficacy 2 did not have a significant reciprocal effect on Identity 2. This finding indicates that the two factors have a one-way within wave reciprocal relationship as suggested in the literature with mathematics identity holding substantial predictive power on students' self-efficacy beliefs in their junior year. The across wave analysis showed a significant positive longitudinal effect from each of the wave 1 factors to their wave 2 versions. Self-efficacy 1 had significant effect (.19) on Self-efficacy 2. Identity 1, similarly, had a significant effect (.62) on Identity 2. As expected, these factors show that, on average, students' self-efficacy beliefs and mathematical identities vary across grades and have longitudinal predictive power. Further, the size of the effects, particularly the effect of Identity 1 on Identity 2 (.62) and Identity 2 on Self-efficacy 2 (.23), are impressive given the three academic semester gap between the data collections. Altogether, the REM supports the cited literature and overall study hypotheses focusing on the importance of students' self-conceptions and their identities impacting their self-efficacy beliefs. Furthermore, the significance of the factors in the REM helps to support the ordered relationship between the two factors, with individual self-beliefs being 'housed' within one's identity.

The remaining models, the *Internal Reciprocal Effects Model* (Model 2) and the *Internal Effects Model* (Model 3), did not provide an adequate fit for the data based on an analysis of fit statistics and thus were rejected. The results of these models are provided in Figures 6 and 7. The fact that these two models were rejected lends strength to within-year mutuality between mathematics identity and mathematics self-efficacy help to structure the theoretical relationship between the constructs.

Based on the literature in conjunction with the rejection of the latter two models, the *Mathematics Identity-Efficacy Connection* will be discussed. The REM, as a result, was utilized to interpret and draw final conclusions from the data. These conclusions were assessed based on the outlined hypotheses. Additionally, a discussion integrating the results of the REM and the literature is also provided in chapter five. Further analyses beyond the scope of this study could have identified potential variations in students' assessments based on their mathematics course and other factors. The concluding chapter provides an extended discussion of these findings, study conclusions, and directions for future research.

4.5 LIMITATIONS

Many studies of this sort seeking to engage interdisciplinary perspectives using quantitative techniques have limitations. However, given the outlined scope of this study, the perspectives and analyses presented help to shed light and provide further confirmation on the structuring of the individual within contexts usually noted in the qualitative and mixed-methods literature. This section details the limitations of this study, specifically those related to the analysis of the data.

Given the two-year gap in data collection and the factors that could have informed shifts in students' beliefs with regard to the study variables, all analytic results were interpreted with caution. These cautions generated limitations during the analysis of data for the current study and presented additional questions for future research. Nevertheless, the results did provide evidence that students' beliefs have strong predictive power for factors that are not consistent across all demographic variables, in addition to students' self-efficacy beliefs and identities, and that these factors are supported by the literature reviewed in the study. The limitations, therefore, noted are based in three primary areas: (1) lack of available data, (2) lack of prior research studies on the topic, and (3) measures used to collect the data.

Lack of available data. The scope of the included analyses was dependent upon the public data made available in the 2009 High School Longitudinal Study. As a result, the types of analyses conducted, and the factors generated to discuss these results, were limited in scope to the questions and question-types available in the student-level file. If provided with additional resources to examine more specific questions to students' beliefs about their mathematical abilities beyond current courses, the scales generated for mathematics self-efficacy could have been suited to focus more on students' beliefs about their algebraic skills and abilities in the models; similarly, the same would have been true if additional questions were available with regard to students' beliefs about their mathematical identities.

Lack of prior research studies on the topic. To my knowledge, no research studies exists which seek to engage theoretical perspectives in an attempt to structure mathematics identity and mathematics self-efficacy constructs using quantitative methods. Further, no studies existed at the time of the literature review that conducted such analyses on African American youth, or any other U.S. racial-ethnic group of color. As a result, the literature and theoretical perspectives outlined, which based the analyses, were dependent upon research topics connecting one or only two of questions using quantitative methods and relating to: identity, self-efficacy, and African American youth.

Measures used to collect data. The lack of additional and appropriate measures to accurately assess African American students' beliefs and attitudes in an attempt to differentiate these students from other groups would have provided more focused evidence in support of the literature. Nonetheless, the assumptions and hypotheses outlined accomplished this goal without issue, yet additional substance to a study of this sort could have been added with a list of additional measures such as, for example, racial identity or students' conceptions of racial stereotypes or beliefs with regard to mathematics identity and self-efficacy. Future research in this area will help to further focus this dissertation study in an effort to better understand what has already been found and analyzed.

CHAPTER FIVE

DISCUSSION AND CONCLUSION

In this concluding chapter, I present a total of two sections that help to summarize the information presented in the first four chapters of the study. The first section of this chapter is a summary of findings, which provides an analysis of the research hypotheses and the findings outlined in Chapter Four. The second section is a discussion of the findings and their connections to the literature presented in Chapter Two and focuses on the implications of this dissertation study for future research and practice.

To generate the findings discussed in this dissertation, I conducted a longitudinal evaluation using data from the High School Longitudinal Study (HSLS) on a sample of 1,362 black youth in secondary schools. The purpose of this study was to understand the structure of theorized relationships between defined identity and self-efficacy constructs in mathematics. Specifically, I wanted to confirm the structure of these two constructs as described by Erikson (1968), Spencer & Markstrom-Adams (1990), and others. Self-efficacy beliefs inform identity development processes and subsequently become a part of the core identity throughout iterations of the identity development phase. These outlined relationships were supported by the data and the literature. Shifts in students' beliefs over time were attributed to a variety of external and internal factors. These factors were included contexts related to students' sense of school belonging, school engagement, and their mathematics learning environments, which underscored the reciprocal nature of environmental effects on the individual. Finally, sex helped to explain returns on a measure of students' Algebraic proficiency, with females scoring higher in the absence of having higher identity and self-efficacy beliefs than males, which supported the research related to school engagement, sex differences, and academic disidentification (Osborne, 1997).

5.1 SUMMARY OF FINDINGS

The results of this study deepen our understanding of students' conceptions of their mathematical identities and self-efficacy beliefs, the co-construction of these beliefs within- and across- grade levels in secondary contexts, the significance of various student-level factors informing shifts in these beliefs, and whether sex differences exist in students' Algebraic proficiency based on an assessment of their mathematical skills and abilities. Furthermore, using the findings of this study, strategies can be developed to help students and adults better develop and maintain positive mathematics identities and efficacious beliefs and strategies about their mathematical skills, particularly in general mathematics learning and assessment-specific contexts.

There were a total of two research questions and seven hypotheses for this study. These research questions and the hypotheses, which were presented together at the end of the second chapter, are outlined in this section with a discussion of each hypothesis. Based on the analyses conducted I discuss the hypotheses and whether or not they held true based on the Seemingly Unrelated Regression and Structural Equation Modeling results. The first research question: "*What factors contribute to variation students' mathematics identity, self-efficacy and Algebraic proficiency in secondary school contexts?*" was based on a total of five hypotheses.

Students' perception of their peer network had significant effects on students' Algebraic proficiency, in addition to their grade 9 mathematics identities. This is in concert with what Walker (2006, 2012) tends to with regard to students' intellectual communities, and the perception of their communities achievement, as a contributing factor to students' success. Walker (2012) noted that traditional research methods may not always capture reciprocal support among students yet trends of these effects on achievement outcomes were noted in this study.

Students who took Algebra 1 in the 8^{th} or 9^{th} grade experienced an increase of 10 and 6 points, respectively, in their measure of Algebraic knowledge than students who had not yet taken Algebra 1 in high school. In Riegle-Crumb's (2006) study, she noted that course taking patterns had a significant effect on students' future course enrollments and subsequent achievement. This finding is supported by her research and helps to foster further support for the need to enroll students in more advanced mathematics courses by starting support earlier in the pipeline (Berry, 2008).

Further, females experienced a marginal effect on their proficiency over males, which is generally in contrast to the beliefs they held during their 9^{th} and 11^{th} grade years. However, based on the work of Borum (2012) and Tucker (2000), it is apparent that further study is needed in this area. As one might expect, students whose families reported higher socioeconomic status also experienced a growth in their Algebraic proficiency, which goes to underscore within-group racial differences that require more empirical study; specifically what helps to explain this growth in proficiency beyond students' socioeconomic status and what similarities exist across different groups.

The first of the hypotheses, hypothesis 1, for the first research question was as follows: Students' perceptions of their peer networks will have a significant effect on their self-efficacy beliefs and identities in mathematics, in addition to other factors, such as their sense of school engagement, belonging, and learning environments. This hypothesis held mostly true. While students' perception of the academic orientation of their peer networks did not have a significant effect on their mathematics self-efficacy beliefs, their perception of their learning environment, sense of school belonging, and sense of school engagement all had a significant effect on their mathematics self-efficacy—these are discussed further in later hypotheses.

The second hypothesis for the first research question, hypothesis 2: Students' school engagement will be significantly related to other contextual factors, in addition to students' self-efficacy beliefs and identities, but especially their sense of school belonging, peer network, and their learning environment also held mostly true. Self-efficacy was significantly related to school engagement. Spencer et al's (1993) research on coping resources to self-processes of African American youth help to support this claim. As also found in their work, there were a host of sex differences. In this study, females were more likely to have a higher sense of school engagement than males. Connectedly, females were less likely to have a higher sense of self-efficacy in both grades 9 and grades 11 than were males, indicating the need for further study. Additionally, students who perceived their peers to be more academically oriented were more likely to have a higher sense of school engagement, although marginally. School engagement was also significantly related to students' perception of their learning environment, as found by Osborne (1997). Each of these effects was both significant and substantial to increasing students' self-efficacy beliefs across the secondary grades.

The third hypothesis for the first research question, hypothesis 3: Students' sense of school belonging will be significantly related to their self-efficacy beliefs and identities, in addition to other contextual factors, but especially their school engagement, peer network, and learning environment held partially true. Similar to school engagement, school belonging was significantly related to mathematics self-efficacy. Of the listed factors, the peer network was the only factor that did not have a significant effect on students' self-efficacy, which was in contrast to prior research. However, as noted before, the factors did have a significant correlation, which means that further study needs to be conducted in this area.

The fourth hypothesis for the first research question, hypothesis 4: Students' perceptions of their mathematics learning environments will be significantly related to their mathematics identities and self-efficacy beliefs held true for the mathematics self-efficacy factor. As was the case with the theoretical framing, this finding indicates that students' perception of their learning environments had a significant effect on whether or not they felt they were equipped to accomplish a specific task during the course of their mathematics courses. This finding follows in line with how Erikson (1959) and Spencer & Markstrom-Adams (1990) structured the relationship between identity and various self-processes. While not significant, there was a marginal negatively directed effect from mathematics learning environment onto students' mathematics identity, which was significantly informed by their mathematics self-efficacy beliefs.

The fifth and final hypothesis for the first research question, hypothesis 5: sex differences will exists across students' assessment of their beliefs, in addition to other affective variables, such as school belonging and engagement held only partially true. There was no significant difference in females' and males' reports of their mathematics identities in grade 9. However, there was a significant sex difference for mathematics identity in grade 11, with females reporting a lower mathematics identity scale score.

This finding indicates that as students continue through the secondary grades, females develop more negative mathematics identities that need to be supported. There was also a statistically significant difference in mathematics self-efficacy for males and females in grades 9 and 11, with females holding lower self-efficacy beliefs than males in both grades. This contribution to the literature helps to support the current research being conducted on sex differences in students' identities, with the added note and focus on mathematics self-efficacy as discussed by Noble (2011). While little to no quantitative work has been done in this area, this finding supports the need to further study how the theorized structure of identity and self-efficacy can inform educators' practices based on notions of community and with the added support of students' networks (Gholson & Martin, 2014; Walker, 2006, 2012).

The second research question, "*How are secondary students' identities and self-efficacy beliefs related and moderated within and across the secondary grades?*" was based on two hypotheses. Overall, students' mathematics self-efficacy beliefs and mathematics identities were significantly related and connected within and across grades, supporting the framework for the *Mathematics Identity-Efficacy* connection presented in Chapter two. However, mathematics identity had a more deterministic role in all of the models analyzed based on the amount of variance the factor accounted for. This finding supported the research literature focused on the temporality and reciprocity of external and internal forces; in this case the sum of variance for context-specific factors held stronger predictive power in students' identity shifts and their beliefs in general. Students' mathematics identities were found to be more stable constructs that were informed by various self-processes and self-beliefs.

The sixth hypothesis, based on the second research question was as follows: Students' mathematics self-efficacy beliefs will be significantly related to their mathematics identities within- and across- grades. Based on the results of the Structural Equation Model, this hypothesis held true. Students' self-efficacy beliefs and their identities were significantly related within each of grades 9 and 11 based on model parameters; however, self-efficacy beliefs did not have a significant direct effect on students' mathematics identities in grade 11 most likely because these two were further disconnected as a result of the two year gap in data collection—students' identities had shifted over the course of that time. Within these relations, mathematics identity held strong predictive power within and across the grades as is noted in the literature.

The seventh hypothesis, based on the second research question, was as follows: Wave 2 measures of mathematics self-efficacy beliefs and mathematics identity will have a significant reciprocal effect on one another, in addition to a significant causal relationship with their respective Wave 1 counterparts, held partially true. Mathematics self-efficacy did not have a substantive effect on students' conception on themselves and their perceptions of others' beliefs about them as a mathematical person due to the structure of the two constructs. Mathematics identity helped to inform students' context-specific beliefs, however. This finding supports the main thesis of this dissertation in the attempt to quantitatively structure identity and efficacy in mathematical contexts among African American students. Namely, the developmental precursors of identity are informed by and subsequently inform students' beliefs and behaviors. The next section attaches this finding, along with the others, to the remaining portions of the dissertation.

5.2 DISCUSSION AND CONCLUSION

As noted previously, the purpose of this study was to understand the nature of theorized relationships between mathematics self-efficacy and mathematics identity among secondary school students; and to identify factors that help to explain shifts in these beliefs and students' assessment of their skills and abilities over time. Using an interdisciplinary framework, I sought to explicitly overlap different perspectives. Using National Data and a sample of African American secondary school students, the study identified the significance of considering the self-efficacy beliefs that students develop as a part of their identity development. From this frame, more attention is paid to the factors that contribute to variation in students' beliefs and learning outcomes, in addition to the ways in which an understanding of efficacy beliefs as portion of an identity framework can help to increase the representation of African American students in advanced mathematics. The overarching purpose of this study was based in the research literature on increasing students' mathematical learning outcomes, entry, and persistence in STEM fields while maintaining anti-deficit frameworks (Harper & Nichols, 2008).

Quite a bit of knowledge has been accumulated related to the importance of students' identity development in the area of mathematics teaching and learning. While the continuation of research in this area is key to understanding the nuances that come along with the practices and strategies being fostered to develop resilience and spark motivation, more research is needed that focuses on preparing students for the specific skills that come along with the study of advanced mathematics. I argue that reframing efficacy as a central factor in the development of student's identities, namely their beliefs about where they are positioned in their abilities, between the types of people who they perceive are mathematically oriented and those who are not, may help to better situate the more dominate identity factors into more specific contexts. As a result, I propose that research on identity development seek to move beyond a sole focus on identity and integrate more specific references to students' beliefs about their abilities in multiple mathematical contexts. In many ways, this will help to contribute to both educators' and students' understanding that mathematical skills are built as a result of their practices which has been found by a number of scholars, see for example Boaler (2009), Nasir (2005, 2009), and Martin (2007). Leveraging these and others perspective will allow both researchers and practitioners to better imagine experiences and potential struggles as informing abilities in future mathematical contexts.

As noted earlier, Berry and Thunder's (2012) qualitative metasynthesis for mathematics education provides a substantive review of these issues as presented in the literature; they discuss a needed "shift from knowledge generation to knowledge application" with regard to many of the issues outlined here (p. 53). As a result, I wish to also detail in this section the ways in which the findings of this study can be applicable to everyday practices in mathematics learning and teaching settings.

Walker's (2014) and Borum's (2012) accounts of black mathematicians lends evidence to how supporting students early in their mathematical endeavors contributes to their likelihood of more advanced mathematics study. In this way, the *Mathematics Identity-Efficacy Connection* regards identity development in mathematics, particularly among students from backgrounds that are traditionally underrepresented in advanced mathematics, as a process in which students not only engage in the practice and study of doing mathematics but come to understand how the subject itself is situated and shifts into a larger context that is at time more centered on their efficacy beliefs, which can serve as a coping mechanism in specific contexts (Spencer et al, 1993). The layer-cake curriculum (i.e., Algebra 1 to Geometry to Algebra 2, etc.) noted in many American schools rarely provides the aforementioned opportunity, as students are more keen to seeing mathematics study as stopping at some particular course or level of study. This further contributes to students' development of a *them* and *us* view of mathematics study, with the them most often reserved for those who continue on to more advanced study.

Identities are complex (Gee, 1999, 2000) and given the strong ties to self-efficacy beliefs, supporting students' knowledge of their perception of their skills is key to increasing resilience and other connected factors (Spencer, 1995). Improving the level of focus on asset-based practices regarding students' beliefs must extend beyond and not be focused solely on praise. Helping students to manage and mitigate shifts in their identities over time is also a key component of the larger development of resiliency (Berry & Thunder, 2015; Spencer, 1995; Spencer & Markstrom-Adams, 1990). This underscores the study's findings in that students' identities shifted and a host of factors helped to inform these shifts.

Demographic factors helped to inform shifts in students' algebraic proficiency. However, the key shift resided in students' identities, which will subsequently go to inform their behavioral outcomes. Namely, understanding the effects of students' self-efficacy beliefs on their mathematics identities can link contexts and extend practices to more focused levels situated around the *self* the individual student in context.

Transformative teaching is one key to this shift. Transformative teaching must engage the goals of democratic education and social justice education (Gutstein, 2009) in a contextualized form. Researchers have examined how such methods help to increase students' conception of themselves as capable. Researchers have provided a useful set of perspectives and tools to contextualize critical pedagogy as a form of transformative teaching for students, and urban youth in particular. Descriptions of various pedagogical components supporting a framework that provides strategies to engage students in the design and management of their learning spaces has been shown to be extremely effective, specifically in STEM contexts. Pedagogical approaches identified as transformative are based on a cultural understanding of students within a particular space, such as a science or mathematics classroom, to develop students' sense of belonging and engagement via understanding. This view is based largely in theories surrounding culturally relevant pedagogy and extends it further into practice (Ladson-Billings, 2014; Paris, 2014). In each of these descriptions, pedagogy is used as a transformative tool to ensure students' knowledge acquisition, and align well with Gutstein's (2009) more mathematical lens related to social justice pedagogies that seek to empower students and their sense of self. The *Communities of Practice* framework (Lave & Wenger, 1991) also provides a way in which students' identities can be supported in these spaces and supports the development of their mathematics efficacy.

In this study, students' mathematics learning environments were significantly related to their sense of school belonging and school engagement. Although students' learning environment did not significantly predict their mathematical identities it did significantly predict students' self-efficacy beliefs, which are structured to inform core identities as students' beliefs become more stable. Previous research has shown the grave importance of students' learning environment to the development of their identities, which, as this research has demonstrated, is closely aligned with students' self-efficacy beliefs. As a more focused representation of students' assessment of their skills, self-efficacy provides a seemingly more appropriate lens to examine how ecological and external contexts in education contribute to students' sense of themselves and their subsequent achievement. In many ways, students' perception of their learning environments will depend on the successful implementation of the overlapping components of pedagogy (Ladson-Billings, 1994), specifically the ways in which students are made to feel as if they belong. These modeled connections have been shown to increase outcomes. There are myriad of other models that have been provided as well.

The concept of the *self* is at the heart of motivation and learning. Given the social-ecological and social-cognitive reality of teaching and learning, the construction of the self is integral to our understanding of the interrelations between more in-depth cognitive processes and external forces in education. In social cognitive theory, self-efficacy has been long identified as a dominant factor of social learning that relates to multiple self processes, such as self-regulation and self-reflection (Bandura, 1989). In ecological systems theory, connected models of human development detail the systems under which these self processes are guided and regulated, for example, in smaller micro-systems and larger macro-systems (Bronfenbrenner, 1979; Spencer, 1995). Learning, situated as a Community of Practice (CoP) (Lave & Wenger, 1991; Wenger, 1998), requires collective processes that demand the interaction between multiple selves to generate knowledge, all occurring within a model of reciprocity. Resultantly, the construction of self-efficacy and identities are both central to theories of learning. Focusing on self-beliefs in education contexts alongside external forces provides rich sources of information to understand and combat compounding and recurring educational disparities.

In social justice and connected critical frameworks set to shift inequitable structures, the self functions as a key component to ensuring that students not only attain requisite knowledge but, more importantly, have the motivation, efficacy and stable identities to transform their knowledge into action. The self-development processes that occur during adolescence provide an ideal setting to concretize students' understanding of these processes. For example, for adults, beliefs about their ability to complete mathematical tasks in various contexts ranging from routine activities, such as budgeting, to more "complex" tasks, such as calculating interest on a loan, began very early during their learning process and determine a significant portion of decision making, behaviors, and subsequent opportunities. Students learning mathematics and science, through activities such as conducting experiments and problem solving, develop similar beliefs about their skills that go on to set the foundation and inform their future selves as adults.

In this study, emphasis was placed on these perspectives to explore the construction of self-efficacy and identity in mathematics during a critical developmental stage for youth. Wenger's (1998) exploration of identity development is situated at the intersection of individual agency and social practices—such as teaching and learning—and culture. From Wenger's perspective, learning is achieved through processes of knowing and becoming. From this lens the co-construction of students' self-efficacy beliefs and identities are reciprocal processes. Further, the complexities innate in these processes are strongly influenced by a multitude of factors that contribute to student learning (Wenger, 1998). Connected literature has provided evidence for these connections.

Adolescent peer networks are one of the central yet under-researched factors contributing to student learning. Peer social ties have been well documented in the literature as integral to the process of students' knowing and becoming, but less often in mathematics (Harris, 2010; Walker, 2006, 2012). Mathematics education research on African American youth in this area has shown that peers contribute to students' meaningful engagement in learning as an integral link between students' "multiple worlds" (Gholson & Martin, 2014; Walker, 2006, 2012), in addition to providing substantial support during students' entry to and persistence through advanced mathematics (Walker, 2014). As Harris (2010) notes, however, quantitative research on peer networks and social ties has varied widely due to the discipline specific perspectives used to measure these networks. However, any examination of the factors that contribute to students' motivation and meaningful learning experiences should attend to the types of peer networks that have been shown to support or deter students' efficacy and the academic beliefs attached to their identities.

Belongingness and engagement in school are also central to this framework; further, they are related to students' relationships with their peers, teachers, and other individuals. Research on African American youth's school belonging has been studied in relation to self-efficacy beliefs and has pointed to the significance of encouragement and aspirations to maintaining these beliefs (Uwah, McMahon, & Furlow, 2008). Connectedly, research on students' school engagement has been noted to vary with feelings of acceptance and beliefs about the importance students place on their educational experiences and the future. These differences, however, were tied largely to the experiences of these students in academic and non-academic settings, and also makes mention of sex differences in students' belonging and engagement. Research on African American youth has also identified the importance of incorporating youth culture to help increase students' sense of self, belonging, engagement, and learning in school.

Surrounding many of the previous influences identified are the processes largely guided by teachers, particularly given the focus on teaching and learning. Research on teachers and in teacher education has pointed to the continued significance of race and culturally based pedagogical approaches (Ladson-Billings, 1994; Leonard, 2008; Mensah, 2013; Sealy-Ruiz & Lewis, 2011). In culturally relevant and social justice approaches, the learning environment becomes critical to ensuring that students' experiences provide ample opportunities for them to successfully develop their efficacy to achieve greater motivation and resilience alongside stable academic identities (Leonard, Brooks, Barnes-Johnson, & Berry, 2010).

It is clear that the abundance of education research and policy focusing on black students utilize a wide array of paradigms and frameworks. Although the subjects under study are grouped by the sociopolitical construct of race the perspectives used to generate knowledge specific to these students in mathematics is often divided among a set of other social and political realities (Martin, 2009a). One common feature of some research in these areas has been, as it should be, to identify the ways in which the student experience can become one that ensures the acquisition of more advanced and technical knowledge for use in society. Thus, there is also a need for more critical quantitative research related to African American youth focused on their enrollment in intermediate and advanced mathematics. Further, these perspectives need to be presented without, for example, the primary goal of ‘increasing the United States’ international competitiveness’ but instead as a tool for liberation (Gutstein, 2009; Moses & Cobb, 2001). There is also a need for research that seeks to remove mathematics as a “gatekeeper” to more advanced courses by examining the ways in which trepidations about advanced mathematical skills can be ameliorated for both students and teachers (Stinson, 2004). Finally, there is a need for more quantitative and longitudinal analyses that make use of nationally representative data to inform future research on black youth, especially from non-comparative frameworks. Altogether, these factors contributed to the overarching goals and research approaches undertaken in the study.

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APPENDIX A

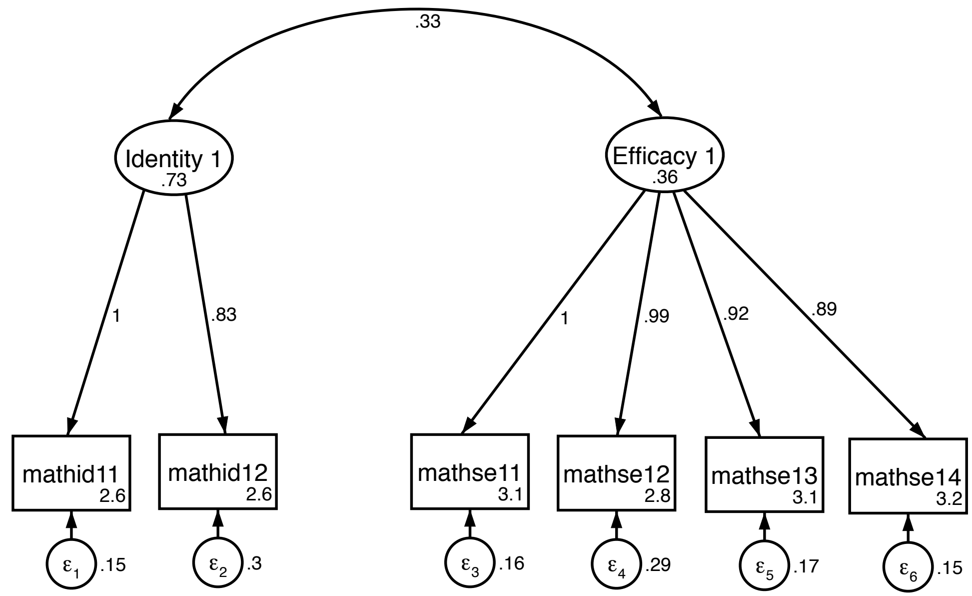
Table 9

Descriptive Statistics for School Belonging, School Engagement, Learning Environment, and Peer Network Measures

Construct / Variable	*M*	*SD*	*Skewness*	*Kurtosis*
Wave 1				
Perceived School Belonging				
1. Feel safe (s1safe)	1.73	.653	.655	3.76
2. Feel proud (s1proud)	1.84	.755	.723	3.38
3. Adult to discuss problems (s1talkprob)	1.88	.781	.688	3.20
4. School waste of time (s1schwaste)	3.29	.756	-0.988	3.81
5. Good grades important (s1goodgrades)	1.33	.549	1.70	6.69
Perceived School Engagement				
6. No homework completed (s1nohwdn)	2.25	.888	.343	2.42
7. No materials (s1nopaper)	1.83	.962	.924	2.79
8. No textbook (s1nobooks)	1.58	.787	1.34	4.38
9. Arrive late (s1late)	1.75	.752	.717	2.97
Perceived Math Learning Environment				
10. Students' ideas valued (s1mtchvalues)	3.17	.746	-0.765	3.53
11. Students treated w/respect (s1mtchrespct)	3.32	.683	-0.934	4.24
12. Students treated fairly (s1mtchfair)	3.22	.769	-0.930	3.76
13. All students can be successful (s1mtchconf)	3.39	.657	-0.916	3.92
14. Mistakes okay if learning (s1mtchmistke)	3.25	.720	-0.851	3.78
15. Some students treated better (s1mtchtreat)	3.06	.898	-0.773	2.87
16. Math made interesting (s1mtchintrst)	2.83	.959	-0.372	2.15
17. Genders treated differently (s1mtchmfdiff)	3.25	.802	-1.046	3.79
18. Math made easy to understand (s1mtcheasy)	3.03	.878	-0.741	2.94
Peer Network – Perceived Academic Orientation				
19. Talk math courses w/friends (s1frndtalkm)	0.24	.427	1.21	2.46
20. Talk science courses w/friends (s1frndtalks)	0.19	.396	1.54	3.37
21. Talk college w/friends (s1frndtlkclg)	0.49	.500	.007	1.00
22. Talk jobs/careers w/friends (s1frndtlkjob)	0.50	.500	-0.003	1.00
23. Talk problems w/friends (s1frndtlkprb)	0.50	.500	-0.018	1.00
24. Gets good grades (s1frndgrades)	1.10	.305	2.59	7.72
25. Interested in school (s1frndschool)	1.23	.425	1.23	2.53
26. Attends class regularly (s1frndclass)	1.04	.198	4.62	22.39
27. Plans to go to college (s1frndclg)	1.04	.213	4.24	19.03

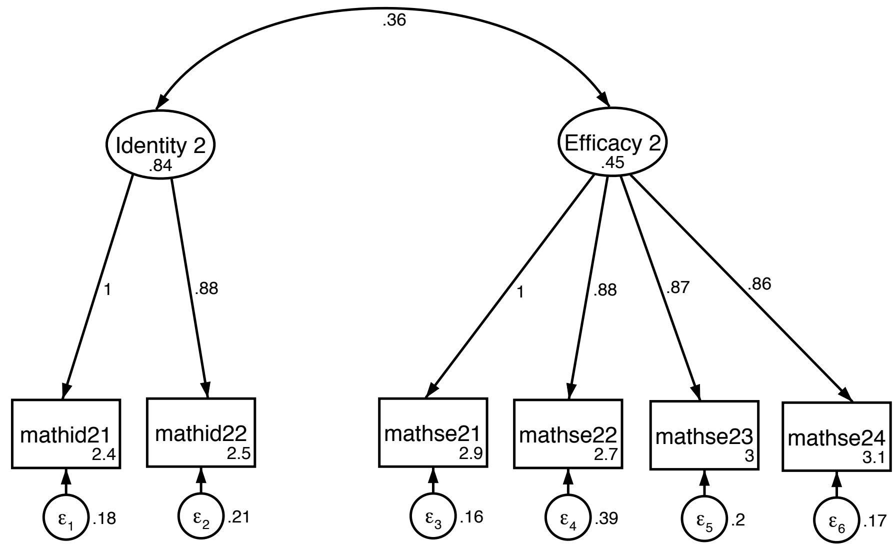
APPENDIX B

Figure 3. CFA Measurement Model for Identity 1 (wave 1) and Self-efficacy 1 (wave 1)



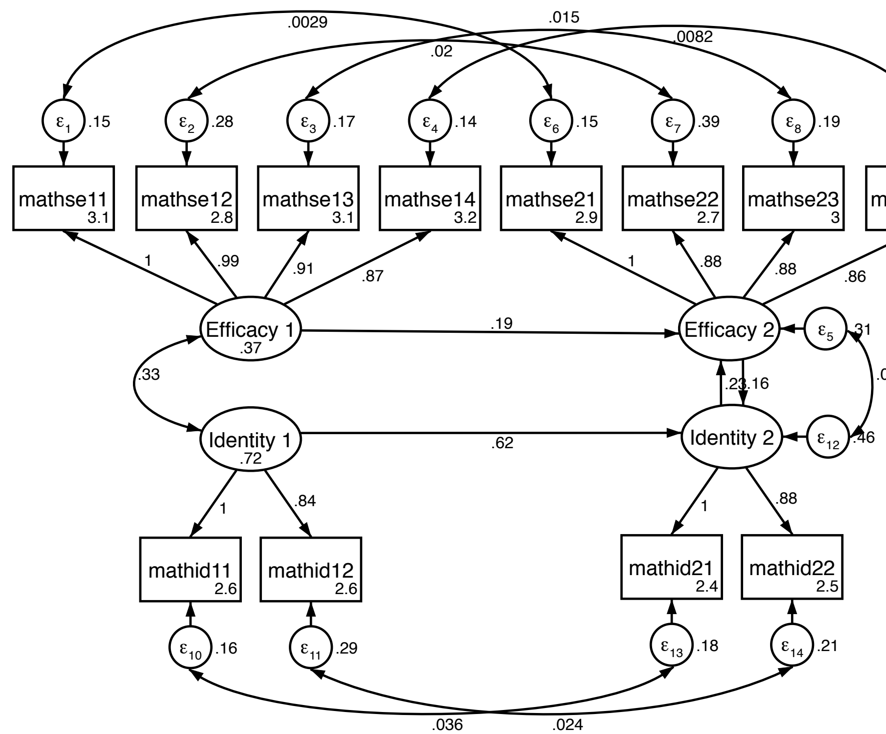
APPENDIX B

Figure 4. CFA Measurement Model for Identity 2 (wave 2) and Self-efficacy 2 (wave 2)



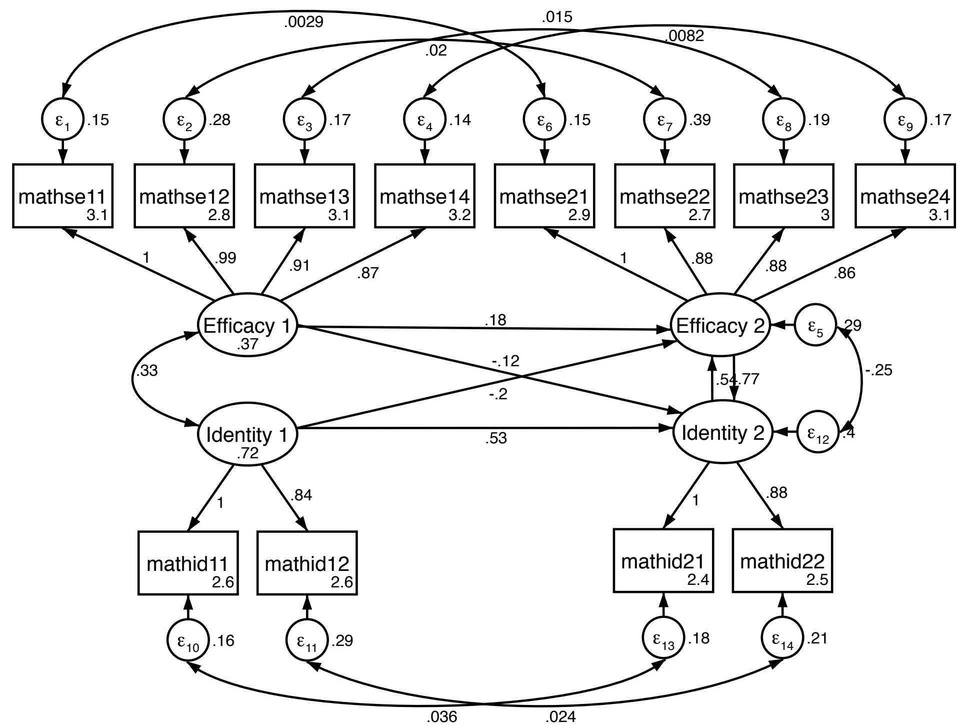
APPENDIX C

Figure 5. Model 1: Reciprocal Effects Model (REM) of the Longitudinal Relation of Mathematics Self-efficacy and Mathematics Identity



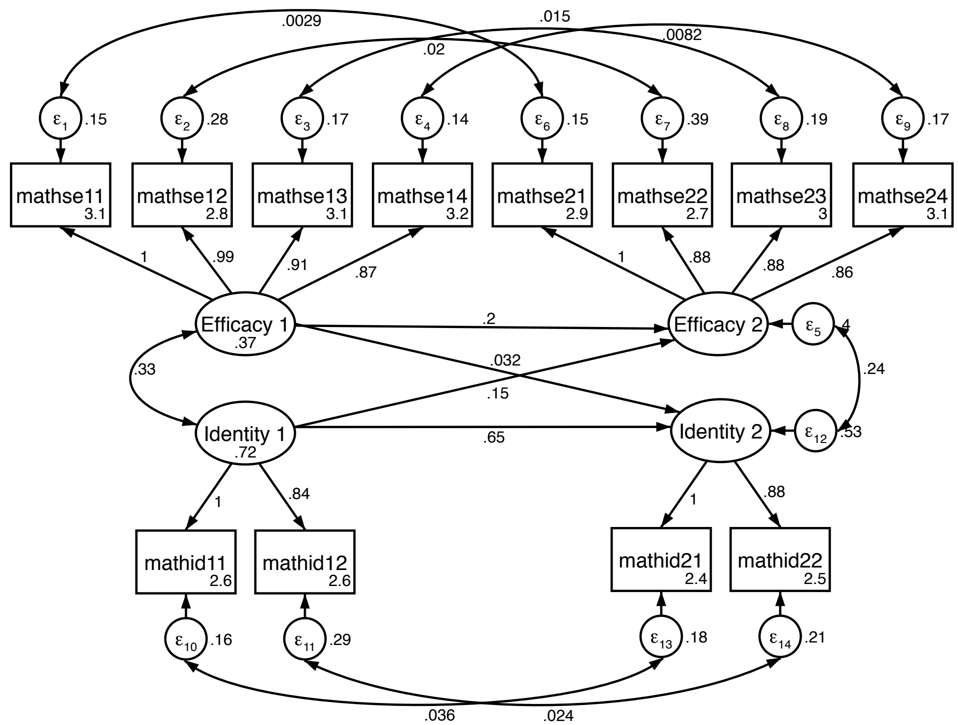
APPENDIX C

Figure 6. Model 2: Internal Reciprocal Effects Model (IREM) of the Longitudinal Relation of Mathematics Self-efficacy and Mathematics Identity



APPENDIX C

Figure 7. Model 3: Internal Effects Model (IEM) of the Longitudinal Relation of Mathematics Self-efficacy and Mathematics Identity



APPENDIX D

Table 10. Evaluation of the Reciprocal Effects Model (REM): Longitudinal relationship between mathematics self-efficacy and mathematics identity (correlations, means, and standard deviations)

	Wave 1						Wave 2					
	Self-efficacy				*Identity*		*Self-efficacy*				*Identity*	
Construct / Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Wave 1												
<u>*Self-efficacy scale*</u>												
1. Excellent on tests	-											
2. Understand textbook	.63	-										
3. Master course skills	.66	.62	-									
4. Excellent on assignments	.70	.58	.67	-								
<u>*Identity scale*</u>												
5. Self perception	.48	.47	.46	.46	-							
6. Others perceptions	.42	.39	.41	.42	.72	-						
Wave 2												
<u>*Self-efficacy scale*</u>												
7. Excellent on tests	.22	.22	.20	.20	.23	.21	-					
8. Understand textbook	.19	.21	.18	.18	.24	.20	.58	-				
9. Master course skills	.19	.20	.22	.19	.20	.19	.69	.54	-			
10. Excellent on assignments	.22	.19	.21	.22	.24	.20	.71	.54	.65	-		
<u>*Identity scale*</u>												
11. Self perception	.30	.31	.31	.28	.54	.44	.45	.48	.39	.41	-	
12. Others perceptions	.29	.27	.27	.29	.48	.45	.43	.43	.40	.39	.79	-
M	3.11	2.83	3.09	3.21	2.57	2.57	2.91	2.65	3.00	3.05	2.39	2.47
SD	.72	.80	.69	.66	.94	.90	.78	.86	.74	.71	1.01	.93

<u>Goodness of fit summary</u>				Contrast with baseline model			
Reciprocal Effects Model (REM)	X^2	*df*	X^2/df	$X^2_{difference}$	$df_{difference}$	TLI	CFI
Baseline (unconstrained)	118.19***	42	2.81	-	-	.98	.99
Factor loadings invariant over time	131.96***	66	1.99	13.77**	24	.98	.99

Note. *N = 1,362 (Wave 1 – Grade 9, Wave 2 – Grade 11); **p < .01, ***p < .001*