Understanding the Leaking Pipeline:

The Effects of Self-Efficacy and Student Choice on High School Mathematics Preparation and STEM Matriculation

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ABSTRACT

This study examines social structural effects on student mathematics preparation and identification with a science, technology, engineering, or mathematics (STEM) field, as well as the social psychological factors that may mediate those effects. Using demographic, academic, attitudinal, and school policy data from the Educational Longitudinal Study of 2002 (ELS: 2002) for over 14,000 students from a nationally representative sample, this research tests a model of mathematics course taking and selection of a STEM field linking social identity and self processes with academic decision making. Using structural equation modeling (SEM) to assess the relationships between the latent and observed variables, specifically examining mathematics self-efficacy and social support variables and how they mediate the effects of background variables and prior mathematics achievement on mathematics course taking and subsequent choice of a STEM major, the initial model tests the use of advanced mathematics course taking as a proxy to a college major in a STEM field.

This study further develops a second model linking social identity and mathematics course taking using the nested structure of the data to consider the role of school grouping policies on mathematics course taking. Hierarchical linear modeling (HLM) is employed to measure the effects of individual socio-economic level, race, gender, and coping resources within schools with different course selection and ability grouping policies on high school mathematics course taking.

The results of structural equation modeling supported most formulations of the conceptual model and showed significant effect of coping resources on mathematics course taking and subsequent STEM matriculation. Furthermore, females showed lower mathematics self-efficacy and were less likely to enter a STEM field of study than males although they experienced higher levels of social support and math course taking. Findings from the hierarchical linear models suggested that students' mathematics course taking was related to coping variables, but it varied by course enrollment policy at the school level. The effects of school policy were not consistent across racial groups. The study had both theoretical and practical significance, providing insights for increased diversity in STEM majors as well as policy implications at the high school level.

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CHAPTER ONE

INTRODUCTION

"America's economic future lies with its next generation of workers and their ability to develop new technologies and products. This means we must strengthen math and science education in the U.S."— Craig Barrett Chairman, Intel Corporation (Tapping America's Potential: Progress Report 2008, p. 8)

In the United States, women, African-American, and Latino students are consistently underrepresented in science, technology, engineering, and mathematics (STEM) fields. In these disciplines, as students move from high schools to colleges, underrepresented students drop out at higher rates than do White and Asian/Pacific Islander males (Green 1989; Hilton & Lee, 1988; Seymore & Hewitt, 1997) resulting in a loss of talented students often called the "leaking pipeline". Concerns about equity make these patterns of involvement by gender and race all the more troubling.

During most of the 20th century, the United States was a world leader in the areas of science, mathematics, and engineering; however, *The Final Report of the National Mathematics Advisory Panel* (U.S. Department of Education, 2008) paints a bleak future in which a large proportion of the science and engineering workforce will retire as job opportunities in this sector continue to grow. According to estimated by the National Science Foundation, the U.S will need 20% more engineers by 2010; however, the pool of qualified graduates is only projected to grow by 2 percent (Loftus, 2008). In addition to equality concerns, loosing the opportunity for a more diverse STEM workforce also impacts the diversity of ideas and interpretations of findings potentially threatening product and/or research quality.

To change the leaking pipeline trend, *The Final Report* (U.S. Department of Education, 2008) points to needed changes in the U.S educational system to strengthen the mathematics and science preparation of American students for the future success of the nation as well as to provide opportunities to individuals and their families. The National Assessment of Educational Progress (NAEP) *National Report Card* (U.S. Department of Education, 2007) shows positive trends in America's mathematics scores in fourth and eighth grades; unfortunately, twelfth grade mathematics scores are less positive with only 23% of American students scoring at or above the "proficient" level. Additionally, there is a growing demand for remedial mathematics courses for incoming students at four-year colleges and community colleges.

There are even larger disparities in mathematics preparation related to race and income. Only 12% of African-Americans take pre-calculus and just 5% go on to calculus (Loftus, 2008). The College Board (1999) reported African-American children were three times as likely to be raised in low-income families as compared to White and Asian children. Hispanic children were twice as likely to be impoverished. Poor students often attend poor schools (Willms, 1986; Wilson, 1985) where prerequisites, like calculus and physics, may not even be offered. School structures such as ability grouping within classrooms and tracking students into different academic programs further segregate children along ethnic and social-class lines (Gamoran, 1992; Kerckhoff, 1986, 1993) and contribute to minority students being traditionally under-represented in advanced level mathematics courses (Oakes, 1985).

Women are also proportionally underrepresented in STEM fields. Similar to the drop-out trends of underrepresented racial minority students in STEM disciplines, women drop-out at higher rates than do men as they move from high schools to colleges (National Research Council, 1991). In addition, the gender imbalance in interest in technology and engineering majors continues—only one in ten computer science majors, and one in seven engineering majors are female—although women's participation in the life, social, and behavioral sciences at the undergraduate level approaches parity (Babco & Ellis, 2007; Pryor, Hurtado, Saenz, Santos, & Korn, 2007). When examining academic reasons for this disparity, unlike the mathematics achievement gap between white students and African-American and Hispanic students, in the past 25 years gender differences in mathematics achievement overall have been declining, with females showing higher scores than their male counterparts in some measures of mathematics achievement (OECD, 2003). Some studies still report a gap in upper-level mathematics course enrollment by females as well as fewer females choosing professions in math, science, and technology (Dick & Rallis, 1991). And, for women who do earn degrees and are employed in a STEM field, they are leaving science, engineering, and technology jobs at twice the rate of men (Belkin, 2008).

At the undergraduate level women are outnumbering men, and racial minorities are attending in record numbers; however STEM majors continue to be primarily white and Asian males. With the changing face of student body composition on many college campuses, the startling differences between STEM disciplines and other areas of study begs the question: How do students experience mechanisms of influence to pursue a career in a STEM field differently, so differently that specific groups are not entering these disciplines in college? This is the central question of this study and, although I cannot purpose to specify and measure all of the intricacies involved, in seeking an answer I have both a theoretical and practical focus. The theoretical focus is on the relationships between social structures, socializing agents and self processes connected to mathematics preparation and entering a STEM discipline. The practical focus is on the need to understand the impact of socializing agents, self processes, and school grouping policies on students underrepresented in the STEM disciplines.

The processes linking individual students with attainment of a STEM career most likely include a complex combination of family background, self processes, educational opportunity and social relationships operating within larger social structures of the educational system and society as a whole. Working from a social psychological framework, this study examines the social and self processes that mediate family and social background and educational outcomes. For our purposes, educational outcomes are conceptualized as products of individual students' actions, specifically mathematics courses studied and choice of major.

Conceptual Framework

Self-Concept and STEM Matriculation

Based on the disparities in the number of STEM graduates between males and females and racial groups, this study begins with two assumptions: (1) to enter and remain in a STEM field of study, one must conceptualize the self as having the abilities required of a professional in a STEM field; and, (2) social mechanisms are at work that shape students' self beliefs about those abilities. Social psychological processes bridge the gap between individual and society by identifying interactions (mesolevel) through which social structures (macrolevel) shape and create meaning for individuals (microlevel). These processes help to illuminate not only the influence of social distribution of knowledge, power, and resources on individuals but the role it plays as a symbol in social interaction.

From the perspective of symbolic interactionism, the context of behavior and interaction of humans is symbolic and interpreted in terms of meaning(s) one develops in the interaction itself (Stryker & Vryan, 2003). In this framework, social life is a dynamic process with society and its settings continuously altered as individuals act toward one another. As social processes shape society, they too shape individuals. From this perspective, society and the individual are intertwined: society creates individuals and the actions of individuals through interaction create society.

Based on the work of many scholars including Mead, Park, Blumer, and Kuhn, symbolic interactionism has been explored, interpreted, and defined in various ways over the past 100 years. For the purposes of this study, I will use Stryker's (1988) specification of premises on which symbolic interactionism rests: (1) accounts of human behavior must incorporate the point of view of actors engaged in the behavior; (2) social interaction is fundamental, with self and social structure emerging from interaction; and, (3) individuals' responses to themselves, their reflexivity, link macro social processes to the interactions in which they engage.

Symbolic interactionism contends that self and society are cocreated; however, self-concept is often seen as a psychological phenomenon (see discussion below). Rosenburg's work (1981) studies self-concept as both a social product and a social force. Rosenburg specifies self-concept as a social creation molded by interactions with others, past experiences in social contexts, and location within a social structure. Therefore, the self (and the self-concept) is a social product. However, a person's self-concept can have an impact on the individual (see Baumeister, Smart, & Boden, 1996) and groups (see Swann, Milton, & Polzer, 2000). Self-concept can influence an individual's thoughts, emotions, and behaviors as well as influencing the groups to which an individual belongs through the manifestation of social problems linked to self-concept. In these ways, self-concept is a social force.

Sociological approaches to the self-concept are broadly characterized by two different emphases (Hewitt, 1979), the "biographical" self-concept roughly defined as a set of meanings attached to the self as an object, and the "situated" self-concept operationalizes self-concept as a shifting process of self-presentation in interactions. For this study, I use Rosenberg's social structural-biographical approach (1979) in which self-concept encompasses: “the totality of the individual’s thoughts and feelings with reference to oneself as an object” (Rosenburg, 1981, p. 595). Defined in this way, self-concept is a complex entity, and for practical study only a specific segment of self-concept is used.

Two well-known dimensions of self-concept are self-esteem, “feelings of self-acceptance, self-respect, and generally positive self-evaluation” (Rosenberg, Schooler, and Schoenbach, 1989, p. 1008) and self-efficacy, “belief in one’s ability [through effort] to master life’s challenges and make things happen in accordance with one’s plan” (Rosenburg & Kaplan, 1982, p.4). Although self-esteem and self-efficacy are related, they are different. Distinction between the two dimensions is demonstrated in some studies of self-concept among African Americans. The self-esteem of African-Americans is typically observed to be similar or slightly higher than that of whites; however, the self-efficacy of African Americans consistently trails that of whites (Gecas & Burke, 1995; Oates, 2004; Porter & Washington, 1982).

In recent years, self-efficacy studies using psychological models have been more prevalent in the work of social cognitive theorists (e.g., Bandura, 1997, 2000; Schunk & Pajares, 2004; Zimmerman, 1998; Zimmerman, Bandura, & Martinez-Pons, 1992) who find people’s feelings of self-efficacy affect various aspects of behavior including activity choice, goal setting, effort and persistence, as well as learning and achievement. In fact, self-efficacy is often found to be more predictive of learners’ performance than self-concept or self-esteem (Bong & Clark, 1999; Bong & Skaalvik, 2003). Although, social cognitive theories share the idea of development of self-efficacy in the social context, and its impacts on behavior are well studied, it is approached from a psychological perspective, not a sociological one; therefore, the implications for self-efficacy as a social force as well as a social product are not considered. For the purposes of this study, a sociological framework will be used to examine the role of social structure; however, findings from the study of self-efficacy in psychology help to explain the relationship between self-efficacy and behaviors.

Stereotypes and the STEM Disciplines

In the U.S., negative stereotypes persist about women and some racial minorities specifically in math and science. In trying to understand the implications these stereotypes have for academic identities and performance outcomes, Steel and Aronson (1995) developed and tested a theory termed "stereotype threat". Based on the theory of domain identification, stereotype threat assumes a student must positively identify with a domain, specifically academics, in the sense that it is part of his or her self-definition or personal identity. With social structural limits on educational access imposed by socioeconomic disadvantage, segregation, and restrictive cultural beliefs, identifying with academic domains is made more difficult. Steele's (1997) work focuses on further barriers for those who have already overcome the initial social structural barriers and are academically identified. A social-psychological threat, stereotype threat arises from a situation in which a negative stereotype about one's group applies. If the student fears being reduced to that stereotype by others in a situation, the emotional reaction caused can directly interfere with performance (O'Brien & Crandall, 2003; Osborne, 2001; Spencer, Steele, & Quinn, 1997; Steel & Aronson, 1995). Furthermore, if the threat is chronic, for example a female student in a competitive male-dominated calculus class, the stress can pressure a reconceptualization of the self to remove the domain (talented math student) to protect the self from the threat. This protection, called disidentification, can reduce or eliminate motivation in the domain and possibly lead to dropping out of the domain altogether.

Stereotype consciousness develops rapidly in middle childhood (ages 6-10) with stereotype awareness even more pronounced in students whose race and gender carry a negative stereotype (McKown & Weinstein, 2003). As students become conscious of academic stereotypes, such as the wide-spread belief that white and Asian males are better at math, students who are not white or Asian males expect others to be judging them based on these stereotypes and therefore underperform. Expectancy states theory may be at play in stereotype threat, as the "threat in the air" is what the underrepresented student expects others believe about his or her abilities.

In addition to race and gender, other locations within the social structure carry prevailing stereotypes. Low socioeconomic status (SES) not only limits students' resources, academic role models, and academic preparation, in the U.S. it is also judged through a cultural belief in the "American dream" that opportunity for economic advancement is plentiful and dependent on effort and skills. Within this belief, individuals are responsible for their own fate, and poor people are stereotyped as lazy or failures (Mirowsky, Ross, & Van Willigen, 1996). In the meso-structure of school, ability grouping or tracking policies are in place for many students. Minority students are traditionally under-represented in advanced levels or tracks (Oakes, 1985), and track placement is often equated with ability promoting the stereotype that students in the lower ability groups are not able to learn, or at least not more complex materials.

Social Structure, Coping Resources, and STEM Matriculation

This study's purpose of studying social structural effects on student mathematics preparation and identification with a STEM field, as well as the social psychological factors that may mediate those effects, may be furthered by considering the sociological study of stress. Based on the findings from the stereotype threat studies, students that are not white or Asian males who are STEM-identified may experience an emotional reaction to stereotype threat when in a STEM domain. Additionally disidentification can occur in the face of repeated threats in a domain. These threats can be perceived as causing stress to the individual, and in an attempt to protect them from stress they disidentify with the STEM domain. Similar to Pearlin's (1989) purpose for studying stress from a sociological framework:

> This search, I believe, will reveal how ordinary people can be caught up in the disjunctures and discontinuities of societies, how they can be motivated to adopt socially valued dreams and yet find their dreams thwarted by socially erected barriers, and how as engaged members of society they come into conflict with others and themselves (p. 242).

Investigating the effects of social psychological characteristics, such as beliefs and resources, on STEM identification provides an important theoretical and empirical link between social structure and individual experience.

Adapted to examine the relationships between social position, resources, and individual outcomes as they relate to identification with a STEM major, the conceptual model is displayed in Figure 1. Social structure locations of interest include those underrepresented in STEM fields, namely women, African Americans, Hispanics, and low SES. The resources for coping with the adversity and stress of being an underrepresented group include the social integration of academic goals with parents, peers, and teachers as well as the personal resources of math self-efficacy and future educational aspirations. If students lack these coping resources the stress of being a STEM minority is not alleviated. The personal outcome is the disidentification with a STEM domain.

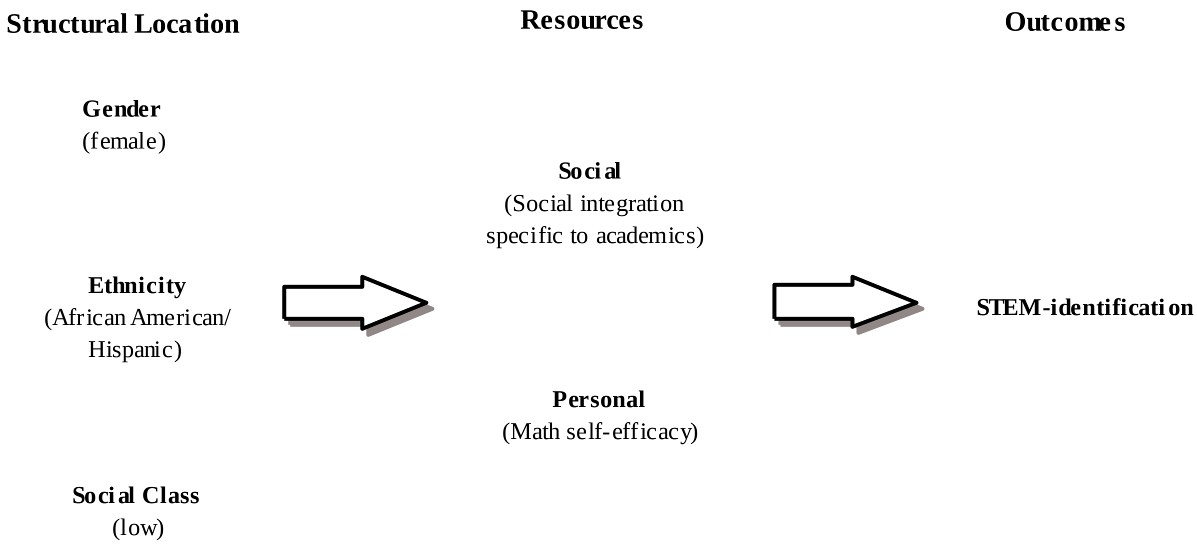

Figure 1. Conceptual model of STEM identification considering social structural location and moderating resources.

The conceptual framework will guide this study's examination of the relationships between social structure and the choice of a STEM major. Although understanding the links between social location and STEM identification is the theoretical focus, the practical focus is school grouping policy effects on mathematics preparation of individuals in groups underrepresented in the STEM fields. Therefore, different sets of analyses are applied to address the two foci of the study.

First, we use structural equation modeling (SEM) to assess the relationships between the latent and observed variables, specifically examining mathematics self-concept and social relationship variables and how they mediate the effects of background variables and prior mathematics achievement on mathematics course taking and subsequent choice of a STEM major. Based on previous research it is expected student interactions with parents, teachers and peers will affect mathematics self-efficacy and subsequent mathematics course taking.

Furthermore, based on prior STEM pathway research, it is expected mathematics course taking will act as a proxy for STEM major allowing for the examination of effects of school grouping practice on mathematics course taking in underrepresented racial groups.

Second, hierarchical linear modeling (HLM) is employed to measure the effects of individual socio-economic level, race, gender, and coping resources within schools with different course selection and ability grouping policies on high school mathematics course taking. With high school mathematics preparation shown to be a significant predictor of STEM major, and with the largest loss of students in math and science occurring in the transition from high school to college, it is important to understand how school policy as well as social location and coping resources contribute to mathematics preparation prior to college.

Using data from the Educational Longitudinal Study of 2002 (ELS: 2002) designed to monitor students' transitions from tenth grade through high school to postsecondary education and/or work using a nationally representative sample, this study seeks to extend the literature on domain identification, the connections between social location and individual behavior and beliefs, as well as ability grouping policies. It is hypothesized that minority status in mathematics and science, which includes being female, African American or Latino, or of low socio-economic background, acts as a stressor through stereotype threat. The stress experienced due to structural location is mediated by the social coping resources of student-parent academic discussions, perceived importance of academics for friends, and perceptions of student-teacher relationships. These social resources are hypothesized to affect the personal coping resource of mathematics self-efficacy with self-efficacy having a direct relationship with mathematics course taking and subsequent choice of STEM major. Furthermore, it is expected school policy on course selection and ability grouping will affect these relationships. The models proposed consider the academic and non-academic variables specific to underrepresented groups prior to college matriculation to better understand student decision-making to further contribute to our understanding of why the leaking pipeline phenomenon persists.

CHAPTER TWO

LITERATURE REVIEW

Underrepresented in the STEM Disciplines

In an attempt to increase the numbers of potential female and minority candidates for participation in STEM careers, researches have investigated the predictors of STEM versus non-STEM career interest and capability, as well as the predictors for persistence in STEM majors. Much of the STEM-specific research on student outcomes focuses on finding ways to retain students in undergraduate STEM majors for degree completion. Other studies have investigated variables connected to learning experiences, enrollment in STEM graduate programs, and improvement of instructional practices (especially in engineering). The literature included in this section is specific to underrepresented groups in the STEM disciplines and considers variables key for females and minorities to select and/or persist in a STEM major.

Bonous-Hamarth (2000) investigated the selection and attrition of minority students in STEM majors. Using Cooperative Institutional Research Program (CIRP) freshman and follow up surveys, the author found strong pre-college academic achievement and personal interest in STEM were positively associated with student persistence. However, gender as well as ethnicity were strong predictors of movement in STEM major. The largest attrition rate from STEM majors was seen in female African American, native American, and Hispanic/Latino students; the second largest attrition group was males traditionally underrepresented in the STEM disciplines.

In an attempt to estimate the probability of a student from a specific underrepresented group graduating with a STEM degree, Leslie, McClure, and Oaxaca (1998) employed logit models with data from CIRP and the National Longitudinal Survey of Youth. The authors found variables that significantly correlated with obtaining a STEM degree for underrepresented minorities included: the student's self-concept, STEM self-efficacy beliefs, future goal commitment, and the social influence of high school peers.

Many of these findings are corroborated in Seymour and Hewitt's (1997) significant qualitative study of why undergraduates leave the sciences. In their three-year study of 460 science, mathematics, and engineering (SME) students at seven institutions, the authors studied attrition using ethnographic interviews to derive testable hypotheses from student reflections. Seymour and Hewitt evaluated how students weighted factors in making the decision to leave SME majors for non-SME majors (termed "switchers"), or the decision to persist despite challenges and setbacks (termed "non-switchers"). Switchers were not very different from non-switchers, they had similar skills and qualifications to master the necessary content, but they evaluated the experience of majoring in SME as highly unsatisfactory due to "structural or cultural sources" (e.g. poor teaching, excessively competitive grading systems, and a lack of identification with SME careers). Although both switchers and non-switchers reported the same problems with their educational experiences, for switchers the problems lead to their leaving the major.

When examining responses based on gender as well as ethnic-racial group, Seymour and Hewitt (1997) reported the loss of capable SME students to non-SME majors in all groups with the strongest differences between switchers and non-switchers described as the social reasons for entering a SME major. The most common reason participants gave for choosing a SME major is the influence, pressure or persuasion of significant others with women reporting this reason more than men. Women also reported entering a major for personal and altruistic reasons rather than for career-oriented reasons. Additionally, women perceived more support from their significant others when deciding to leave the SME major than did men. Students of color reported unique reasons for pursuing SME degrees including long-term contributions to family and community.

In further analyses of group differences, Seymour and Hewitt (1997) observed female SME students were more sensitive to personal relationships than are their male counterparts. Women reported the culture of SME in academe, competitive and designed to "weed out", is impersonal and hostile compared to the more encouraging environment of high school. Having personal and supportive relationships with faculty was the most frequently reported need of women in the study. Furthermore, students of minority status (gender and ethnicity-race) reported feeling ill at ease, a lack of belonging, intimidation, and a loss of self-confidence. Unique to students of color, four factors were most responsible for attrition: 1) differences in ethnic values and socialization, 2) internalization of stereotypes, 3) ethnic isolation and perceptions of racism, and 4) inadequate support systems.

Overall, prior research on STEM participation has explored the influences and key variables for predicting student achievement of a STEM degree. STEM-minority status (being female and/or African American/Hispanic) is also a significant factor when considering the strength of relationships between predictive variables and STEM outcomes.

Developing a Model of STEM Matriculation

For the purpose of developing a model to better describe group differences in STEM majors, an integrative framework is needed spanning disciplines, subcultures, and historical trends in educational equity. In this section, I discuss selection of inputs into the framework based on prior research from social psychological studies, social cognitive theory, and attrition frameworks. Beginning with barriers to achievement, I discuss broad contextual factors such as the macro structure of school grouping and course choice policy, as well as, group culture and social class impacting underrepresented groups; next, I explore proximal inputs considered social resources; and, how group membership, culture, and social resources impact efficacy beliefs, mathematics course taking, and choice of STEM major.

Components from Previous Frameworks

Social psychological research considers social location, differential social and personal resources, and individual affective outcomes when conceptualizing the stress process. Thus, the stress model has proven effective for linking social structures to individual self-concepts. For this study, the primary components of the stress model are used to conceptualize background variables, social and personal resources, and outcome variables into a coherent model.

The stress model has three primary components: stressors and strains, moderating resources, and individual outcomes (Pearlin, 1989; Pearlin & McKean, 1996). Thoits (1995) summarized the model as:

> 1. Individuals' locations in the social structure differentially expose them to stressors which, in turn, can damage their physical and/or mental health;
> 2. This damage is generally moderated or lessened by individuals' social and personality resources and the coping strategies that they employ; and,
> 3. The possession of psychosocial resources and the use of particular coping strategies are socially patterned in a way which, at least potentially, may leave members of disadvantaged groups more vulnerable to the harmful physical and psychological effects of stress (p. 68).

Using the primary components of the stress model to conceptualize the connections between background variables and outcome variables through social and personal resources, previous research using social cognitive theory and attrition frameworks provide insight into the key variables linking social location and decision to continue with mathematics course taking and pursue a STEM major. Many of the constructs and relationships found significant in work by social cognitive and attrition researchers are used within the stress model components.

The pursuit or avoidance of STEM course taking and STEM majors is often researched using a framework of social cognitive career theory, or SCCT (Lent, Brown, & Hackett, 1994, 2000). Rooted in Bandura's (1986) work, a social cognitive theoretical framework was first applied to career choice by Betz and Hackett (1981) and was further refined by Lent, Brown, and Hackett (1994). The theory includes interrelated models of interest, choice, and performance incorporating an overlapping set of person, environmental, and behavioral variables to explore the flow of academic and career development (Lent et al., 1994). Career choice processes and behaviors are contextually bound to environmental variables including socioeconomic status, social support, family influences, and barriers. Cognitive person variables such as self-efficacy and outcome expectations are considered as well as other personal characteristics such as ethnicity and gender. The SCCT model was used by Lent and colleagues (2003, 2005) to explore the relationship of supports and barriers among engineering students. After successful use of the SCCT model using samples of primarily White male students (Lent et al., 1994, 2003) for predicting STEM career choice and attrition, another study was conducted with students (75 percent male) at a predominantly White institution and two historically Black colleges/universities (HBCUs) (Lent et al., 2005). African American students at the HBCUs had higher degree completion rates and reported strong levels of environmental supports with weak barriers.

Lent's work with the SCCT model effectively represents connections between career choice and contextual variables; however, it has only sampled college students who matriculated to engineering majors, not considering students who chose not to major in engineering when transitioning from high school, and it lacks predictive power for gender and ethnic minorities in predominantly White institutions. Expanding this literature to include high school and the transition to college, the current study uses similar constructs as the SCCT model, including support variables and self-efficacy, to develop a model examining the impact of these constructs on course taking and the decision to pursue a STEM major.

In addition to Lent's work, Tinto's research, and the follow-up work of other researchers on student attrition, was also considered for the current study's model development. Although not specific to STEM fields, Tinto's (1988, 1993) model of student attrition focuses on students transition from high school to college, it asserts that college students journey through three stages of transition as they adjust and become assimilated into college life: separation, transition, and incorporation. The degree of transition required is directly related to the differences between the individual's life at home and the community life of the college. During this transitional period, which Tinto divided into three stages, the student departs from his or her family and high school community and begins to transition to a new identity as a college student. During the first stage, separation, the student must let go of his or her identity with high school and family. For successful separation to occur, students must remove themselves and consciously disassociate from their former communities. This process can be very challenging and lead to feelings of isolation. In the second stage, transition, students learn the behavioral norms associated with the college community. This stage is marked by stress, sadness at losing what was left behind, and feelings of being overwhelmed. Some experience stress to a greater degree than others. If a student's communities of the past (e.g., family, high school) are largely different from that of the college, the student encounters more difficulty in adjusting. During the third stage, incorporation, the student explicitly becomes a member of the university by adopting the social norms of the community. The process of integration involves both academic and social transitions. Challenges during the period of incorporation arise when behavioral norms are not always clearly outlined for the student. The completion of this transition is marked by the student forming relationships with others at the institution and acquiring a sense of ownership and belongingness to the college community.

Expanding on Tinto's model, Christie and Dinham (1991) examined the role of external influences, such as family and friends, on students' transition and incorporation. They found that external pressures have a stronger influence on transition than Tinto (1988, 1993) had first suggested. Tierney (1992) suggested that Tinto's (1988, 1993) model was inadequate, especially when related to minority students, because it requires minority students to assimilate and incorporate into a culture different from their own. Based on these findings, the inclusion of influences of family and friends were included in the proposed model of the current study.

In a study testing Social Cognitive Career Theory's (SCCT) academic performance and persistence models using a two-stage approach that combined meta-analytic and structural equation modeling methodologies (Brown, Tramayne, Hoxha, Telander, Fan & Lent, 2007) connected the work of Tinto to findings from tests of the SCCT model. First, indices of academic aptitude (general cognitive ability and high school performance) did not directly relate to college retention. Rather, their influences on retention were largely indirect via their influences on self-efficacy beliefs and completion goals. This suggests that academically able students are no more likely to finish college unless they develop strong confidence in their college academic capabilities and robust goals for college completion. Additionally, prior findings that aptitude alone is not a strong predictor of college completion (Tinto, 2006) were supported. Brown and colleagues suggest future research assessing how other non-ability variables (e.g., social integration, achievement motivation) may complement self-efficacy and goals as predictors or determinants of college retention.

Based on the work of Tinto as well as Lent and colleagues, the inclusion of ability and past performance variables as well as non-ability variables are necessary for the effective modeling of students' academic decisions as they transition from high school to college as well as selection of a STEM major after successful matriculation. The SCCT model has been aimed at identifying theoretical mechanisms that might promote greater involvement of women and persons of color in STEM fields; however, it has primarily been tested on college students already in STEM majors and students report on supports and barriers at the college-level. Studies report women and underrepresented minorities drop out at higher rates as they move from high school to college and therefore do not matriculate into STEM majors (Green, 1989; Hilton & Lee, 1988; Seymore & Hewitt, 1997). Therefore, it is important to consider the academic and non-academic variables of the model specific to underrepresented groups prior to college matriculation to better understand impacts on student decision-making in high school.

The focus of this study is to more effectively model the decision to declare a STEM major by students traditionally underrepresented in the STEM field; therefore, the SCCT ability and non-ability variables are included. However, in this study, the variables are considered within a stress-process framework, framing minority status as a stress-inducing, lower structural location. As discussed further in this chapter, students that experience a situational threat, such as minority status in a STEM classroom, are more likely to experience an emotional reaction in the midst of domain performance (Steele, 1997). Borrowing from the stress literature, this emotional reaction could also be termed minority stress (Meyer, 2003); therefore, personal and social variables are described as coping resources, and mathematics course-taking and declaration of STEM major are described as personal outcomes in a model addressing underrepresented groups.

Predictors of STEM Persistence

As mentioned earlier, STEM-minority status has a significant impact on the strength of relationships between predictive variables and STEM outcomes. Research presenting predictors of STEM pursuit and persistence point to academic skills and personal characteristics as well as group membership. Collectively the results indicate strong mathematical skills, high academic achievement, and personal motivation are important factors for students pursuing STEM degrees.

Several important studies of predictors for STEM major completion are specific to the field of engineering. Zhang, Anderson, Ohland, and Thorndyke (2004) examined predictors of engineering graduation as well as time-to-graduation. Using multiple logistic regression on data from the Southeastern University and College Coalition for Engineering Education (SUCCEED), the study found gender and ethnicity were significant predictors of graduation. However, gender was not a consistent negative or positive predictor across sets of universities, the effects of being male or female on graduating with an engineering degree was dependent on the institution.

Drawing evidence from the eleven-year college transcript history of the *High School & Beyond/Sophomore Cohort Longitudinal Study,* Adelman (1998) examined the engineering undergraduate careers as well as the high school transcripts, test scores, and survey responses of a national sample. His analyses found the pursuit of a college degree in engineering was related to taking advanced mathematics and science courses in high school. Additionally students with high overall academic achievement and quantitative test scores were more likely to pursue engineering degrees although fewer females were on an engineering pathway than males. In his examination of student careers, Adelman describes *curricular momentum*, the influence of curricular factors on how students explore and choose majors. These student trajectories can provide pathways within engineering, preferred pathways for students leaving engineering, and create barriers for students who may show interest in entering the engineering field.

Based on the STEM educational literature, strong mathematical skills and high-level mathematics course taking prior to college are significant predictors of student persistence in STEM majors. However, students traditionally underrepresented in STEM majors and careers often face barriers to the necessary academic preparation for successful matriculation and completion of a STEM degree.

Barriers to STEM Participation

Academic Preparation

Previous research has described math course-taking patterns characterized by strong ethnic/racial disparities with African American and Latino students taking fewer advanced math courses by the end of high school as compared to their White peers (Jones et al., 1992; Ladson-Billings, 1997; Lucas, 1999; National Center for Educational Statistics, 2001; Oakes, 1990). Furthermore, compared to their white and Asian counterparts, African American and Latino students often experience greater achievement barriers, underrepresentation in college, lower college completion rates, relatively low academic achievement, a tendency to disengage from the academic environment, and a disproportionate representation in remedial courses (Davis & Jordan, 1994; Graham, 2004; Sirin & Rogers-Sirin, 2005; Oakes, 1990). These school-based patterns serve as barriers to college admission, selection of a STEM major, and success in earning a STEM degree for many minority students.

When examining the academic preparation of female students, the overall gendered patterns of advanced level math course taking show evidence of parity with females as likely to take Precalculus and Calculus as their male counterparts (Freeman, 2004; Xie & Shauman, 2003). However, while female students show improvements in mathematics course-taking generally, in a 2004 study Freeman found gender differences in subject areas were more prevalent when participation in advanced placement programs was considered. More boys took advanced placement exams in subject areas such as Calculus, Computer Science, and Science, while more girls took advanced placement exams in subject areas such as English and Foreign Languages. When examining the Advanced Placement scores, boys earned higher scores on Advanced Placement exams in each subject area.

The hierarchical nature of math course taking and course prerequisites create an advantage for students who begin high school taking higher-level courses (Schneider, Swanson, & Riegle-Crumb, 1998); where students begin their math sequence in high school is strongly related to the level of courses they take upon graduation (Lucas, 1999). Studies of math pathways show if students do not begin high school taking Algebra I or Geometry they are not likely to take Trigonometry and Calculus, and it is these higher-level mathematics courses that most strongly predict college attendance (Adelman, 1998; Schneider, 2003).

However, beginning high school in Algebra I or Geometry is not the only predictor of course-taking, especially for minority students. Evidence from research on the course trajectories of minority studies shows African American and Latino students are more likely to “fall out” of an initial position of advantage compared to their White peers (Hallinan, 1996; Lucas, 1999; Oakes, 1990). A recent study by Riegle-Crumb (2006) examined the math course-taking trajectories of students of different racial-ethnic groups and genders using nationally representative data. She found African American and Latino students were less likely to begin high school in Algebra I than their Asian and White peers. However, when African American and Latina females did begin high school in Algebra I they reached comparable levels of math with White female students. Unfortunately, African American and Latino males did not see this benefit: in addition to be less likely to begin high school in Algebra I, even if they did begin in Algebra I they fail to reach the same levels of math as their White male counterparts. Therefore, for African American and Latino male students their disadvantage in initial course-taking is exacerbated by a reduced level of return from their math courses early in high school.

These inequalities in math course-taking pathways point to school-based mechanisms for continued race-ethnicity stratification of opportunities for postsecondary matriculation, especially in the math and sciences. To examine possible mechanisms for these barriers, first, school-based policies affecting equity are discussed; then, theories attempting to explain educational trends evidenced by involuntary minorities are presented.

School Effects

Often framed within models of individual choice, research on student course-taking primarily emphasizes the role of career value, interest, and performance in shaping student decisions about subject choice (Barnes, McInerney, & Marsh, 1999; Eccles, 1984; Stokking, 2000). Choice models consider the influence of parent and teacher encouragement and have been found effective; however, the choice approach does not usually address the constraints on student course-taking caused by school factors such as course offerings and grouping policies. Research has found schools make assumptions about the abilities and needs of their student population, and these assumptions were found to guide decisions about course-offerings (Oakes, Selvin, Karoly, & Guiton, 1992). Students in predominantly working-class schools generally have less access to advanced science and mathematics courses (Oakes, 1990; Spade, Columba, & Vanfossen, 1997). In addition to course-offerings student access to courses may be limited by the grouping policies of the school with students in lower ability tracks less likely to have access to advanced courses (Oakes, 1990).

Tracking, historically referred to as the practice of grouping high school students by ability into a series of courses with a differentiated curriculum, placed students in high, middle, or low-level classes, labeled college preparatory, general, or vocational, and students rarely moved between them. Students placed in higher level classes cover advanced material at a faster pace than those placed in lower achieving classes. Although this type of tracking has declined in recent years, versions of ability grouping are still in place in America's secondary schools. The effects of being placed in low-level classes have been studied extensively especially for gender and racial minorities (e.g., Betts & Shkolnik, 1999; Gamoran, 1992; Hoffer, 1992).

Proponents of grouping acclaim it for its ability to accommodate disparate student needs, abilities, goals, and interests therefore having the potential to raise the aggregate level of achievement. However, many researchers argue that grouping practices promote ineffective instructional arrangements which widen the achievement gap by channeling poor and minority students into lower achieving groups or tracks (Leonard, 2001; Schumm, Moody, & Vaughn, 2000; Saleh, Lazonder, & Jong, 2005; Vanderhart, 2006). Oakes' (1985, 1990, 1992) research on the negative consequences of tracking policies suggests that tracking perpetuates low academic expectations, limits access to knowledge, and causes unequal distribution of teacher quality across track. The negative consequences of these educational inequities have the most profound effects on minority students.

In a recent study using the NAEP database, Vanderhart (2006) noted that ability grouping is most prevalent in schools with a large population of minority students, diverse levels of achievement, and impoverished students. Moreover, schools are more likely to track students when there are racial and cultural conflicts. Achievement groups may therefore have potentially harmful effects for minority or low-achieving students. Similarly, Marks (2005) argues grouping can result in the ethnic segregation of students leading to lower levels of educational attainment for immigrant students.

In an examination of grouping in secondary schools, Hoffer (1992) used data taken from the Longitudinal Study of American Youth (LSAY) to compare the math and science performance of seventh to ninth grade students from schools with grouping with those from schools without grouping. Hoffer found that advanced students gained positive benefits from placement among their peers, while learning among low achievers deteriorated under the same conditions.

Based on these findings, it has been argued the gain in achievement by high ability or high-group students is a result of a more challenging curriculum, a faster pace of instruction, and more experienced teachers; if the course content is constant, the achievement gains are not evidenced. Therefore, student grouping has an “instructional effect”: that is, the interaction dynamics governing the teacher-student relationship differ based on student achievement (Gamoran, 1986). In high-ranking groups and tracks, teachers tend to teach more and students tend to learn more; those students therefore have greater opportunities to learn.

Researchers advocating reform (Oakes, 1990) argue that gifted programs and classes with advanced curricula should be offered to all students. The research of Burris, Heubert, & Levin (2006) supports this argument: using a longitudinal quasi-experimental cohort design, they investigated the effects of providing an accelerated mathematics class in heterogeneous middle schools in a diverse suburban school district on the completion of advanced high school math courses and overall math achievement. Their results showed that subsequent completion of advanced courses was more likely for all groups, including minority students, students of low socioeconomic status, and students at all levels of initial achievement. They also found that the performance of high achievers did not suffer in heterogeneous groups when compared with homogeneous ones. Betts and Shkolink (2000) examined the effects of grouping on students' math achievement, as well as on the allocation of school resources. Their analysis of the Longitudinal Study of American Youth (LSAY) database showed little or no differential effects for high-, average- and low-achieving students when class size, teacher education, and teacher experience were similar.

A large body of research examines the effects of tracking and ability grouping. However, with the dismantling of formal tracking programs in the 1970s current research often focuses on the mechanisms through which tracking might have effects (Lucas, 1999). In his book, *Tracking Inequality,* Lucas (1999) discusses school organization after the dismantling of overarching tracking policies referring to school changes to address student groupings as "the unremarked revolution". In the new era of school policy, often schools adopted policies allowing students to choose their courses through open-enrollment policies. The system of open-enrollment appears to create opportunity allowing for mobility; however, the new system has the potential to create a hidden tracking system. Despite the apparent opportunities created by this change, in-school stratification systems continue, and students are self-selecting out of higher-level mathematics resulting in persistent patterns of course taking for minority and disadvantaged students.

Research conducted by Bradley and Charles (2004) as well as Van Langen, Bosker, and Dekkers (2006) explored the connection between comprehensive systems (those with standard curricula for all students) and stereotyped choices using international data. They found educational systems with curricular differentiation, as opposed to comprehensive systems, evidenced greater sex segregation across fields of study. Their argument for this finding is twofold: First, in differentiated systems, there is more opportunity for student choice and academic placement; therefore, there is also more opportunity for gender-stereotyped choices. Second, student choices regarding course-choice and course-rigor are generally made during adolescence, when pressure to conform to sex-role stereotypes is greatest (Bradley & Charles, 2004).

Based on the recent findings from research on student tracking, it can be argued tracking systems with differentiated curricula are most detrimental for students in low-level classes, especially females and students of color. However, student choice into their courses also may prove to be problematic as students are choosing courses in adolescence, a time when individuals are most sensitive to cultural stereotypes. This study considers the impact of student choice on mathematics preparation in high school.

Oppositional Culture

In an attempt to elucidate possible causes for minority-based achievement barriers, Ogbu (1978) presented a discussion of oppositional culture in which involuntary minorities, such as African American and Latino adolescents, perceive a greater social stigma tied to academic success than the majority culture, and therefore see fewer academic rewards and fewer opportunities in education and the future job market (Ainsworth-Darnell & Downey, 1998). Further supporting the theory of oppositional culture, Farkas, Lleras, and Maczuga (2002) found that on National Assessment of Educational Progress (NAEP) data, fourth grade African American, Hispanic, American Indian and low-income students reported a greater rate at which ‘‘my friends make fun of people who try to do well at school’’ than did White and middle-income students.

Identity-Based, Stereotype Threat

The phenomenon of academic disidentification has also been proposed to explain lower academic achievement among minority students, especially African American adolescents (Cokley, 2002; Osbourne, 1997; Steele, 1992, 1997). Steele (1992) posited the social context of an academic environment contributes most significantly to a minority student's disidentification with academics because it is in this context students learn how little they are valued in society. When a student's minority racial status is made salient (e.g. five African American students in a lecture hall of 100 predominantly white students) the cultural stereotype that school success is not an in-group norm links strongly with an individual's self-concept in the academic domain. With negative stereotypes made salient, students experience higher levels of psychological dissonance, termed stereotype threat, this cognitive dissonance is linked to lower achievement in African American students. To preserve self-concept, minority students do not include the academic environment when self-evaluating and seek other outlets to feel positive about themselves (Steele, 1997).

In a study of national trends in academic attainment, study time, and student beliefs about education using the National Assessment of Educational Progress data, Ferguson (2001) found that among African American, Latino, and White youth lower status minority students may come to believe that fitting in with their in-group requires acting in ways incongruent with school engagement. The students who disengage do not see their in-group as represented in the broader school environment, and school engagement is perceived as a characteristic of "others" in the academic majority. The students believed their incongruent actions were necessary to fit in with their in-group even when they individually valued school.

Although academic identity-based research implies a high risk for low-status, minority, and stigmatized groups, the effects are not consistent for all groups and sub-groups. Using the National Educational Longitudinal Study dataset to examine the long-term effects of academic disidentification among African American adolescents, Osbourne (1997) found African American males showed strong patterns of academic identification from eighth to twelfth grades while academic disidentification for African American females was relatively weak. In a study of African American college students, Cokley (2002) tested the strength of association between GPA and academic self-concept over two years of college. The findings are similar to those from the Osbourne (1997) study: males, but not females, showed a sharp decrease in the strength of association between GPA and academic self-concept over time. These findings seem to support that stereotype threat in academic environments is connected more strongly to academic disidentification in African American males than females.

Perceived Discrimination and Stress

The psychological dissonance described in stereotype theory can cause an emotional reaction directly interfering with domain performance (Spencer, Steele & Quinn, 1999; Steele & Aronson, 1995). To better understand the connection between stereotype threat and academic outcomes, examining studies of stress may prove helpful. Sociological studies of stress focus on the social antecedents, patterns, and consequences of distress (Aneshensel, 1992; Thoits, 1995). Examining stress, emotional experience, or other individual level phenomenon without attention to distribution across social strata assumes independence of social location and neglects consideration of social causation for such phenomenon. As Pearlin explains: "Many stressful experiences, it should be recognized, don't spring out of a vacuum but typically can be traced back to surrounding social structures and people's locations within them" (1989, p. 242). The stress process as conceptualized in sociological research considers social location, differential resources, and individual affective outcomes, thus making it an apt model for linking social structure to disidentification.

One problem in stress research is the ambiguity of the meaning of "stress." Stress broadly encompasses a host of negative subjective experiences and their impact on well-being. Harrell (2000) argued that experiences of racism are a unique source of chronic stress for ethnic minorities distinct from other general life stressors. Similarly, in a study of gay, lesbian, bisexual, or transgender persons, Meyer (2003) described *minority stress* as "the excess stress to which individuals from stigmatized social categories are exposed, often as a result of their …….minority position" (p. 675). The perception that one is the target of discrimination may differ in impact from other negative life events for the following reasons: (a) discrimination denies access to resources critical for adapting to other stressors at all levels, as well as opportunities necessary for personal growth and well-being (Clark, Anderson, Clark, & Williams, 1999); (b) discrimination may be perpetrated through individual interactions but is also affected by institutional policy (Harrell, 2000); and (c) the perception of both individual and institutional discrimination may lead to the development of learned helplessness, lower self-esteem, or depression (Greene, Way, & Pahl, 2006; Lee, 2003, 2005; Liang, Alvarez, Juang, & Liang, 2007; Liang & Fassinger, 2008; Liang, Li, & Kim, 2004).

Stress originates from stressors, such as undesirable and uncontrollable life events as well as challenging circumstances or barriers in the environment, and strains stemming from role demands and conflicts (Aneshensel,1992; Pearlin 1989; Thoits 1995). Empirical evidence from stress research confirms that location in the social structure influences a person's chances of encountering stressors and strains. Dion, Dion, and Pak (1992) found a significant relationship between experiences of discrimination and distress after statistically controlling for general stress among community members of Chinese heritage. After controlling for general stress, Pieterse and Carter (2007) found racism-related stress accounted for a significant increment in psychological distress for African American men. In addition, socially patterned deficits in resources for coping with stressors have been found to exacerbate their effects (Aneshensel, 1992; Pearlin, 1989). Reducing or resolving problems, avoiding or diminishing distress, and preserving a positive sense of self are signs of stress buffering (Aneshensel, 1992; Pearlin and Schooler, 1978; Thoits 1994). Often, however, those exposed to the most stressors and strains – individuals in a social location associated with less power-- tend to have the fewest resources for coping with stress (Pearlin, 1989).

The stress process model (Pearlin, 1999) describes three primary conceptual components: stressors and strains, moderating resources, and individual outcomes (Pearlin, 1989; Pearlin & McKean, 1996). The two primary coping resources, personal resources and social resources, buffer individuals from the structural effects of distress (Aneshensel, 1992; Pearlin, 1989; Thoits, 1994, 1995). Personal resources include self-esteem and self-efficacy (Aneshensel, 1992; Pearlin, 1989; Thoits 1994, 1995), and social resources include perceived social support (Aneshensel, 1992; Thoits, 1995) and social integration (Pearlin, 1989).

Coping Resources

Differences in current and future academic outcomes among students may be due to the coping mechanisms of self-efficacy beliefs (Saunders, Davis, Williams, & Williams, 2004), future education orientation (Brown & Jones, 2004), and the support they receive from others for their academic pursuits (Gutman & Midgly, 2000; McGrath & Repetti, 2000; Smith, Schneider, & Ruck, 2005). STEM minority students are more likely to experience stress within academic social structures possibly leading to STEM disidentification. However, the coping mechanisms of self-efficacy, parent, teacher, and peer supports can act as resources to buffer stress enabling students to achieve on the pathway to STEM matriculation.

Personal Resource

Self-Efficacy

According to self-efficacy theory, individuals develop self-perceptions of capabilities instrumental to the goals they pursue and the control they exercise in their environment (Bandura, 1977). Bandura, and other researchers who build from his ideas, find people are more likely to attempt a behavior when they believe they are capable of success—they have high self-efficacy (Bandura, 1982, 1989, 2006; Schunk & Pajares, 2004). Self-efficacy can affect different aspects of behavior including activity choice, goals, effort and persistence, and learning and achievement (Bandura, 1997, 2000; Schunk & Pajares, 2004; Zimmerman, 1998; Zimmerman, Bandura, & Martinez-Pons, 1992). Eccles, Wigfield, and Schiefele (1998) found students with high math self-efficacy beliefs were more likely to enroll in mathematics courses than students with low math self-efficacy. Goal setting is also affected as individuals set higher domain-specific goals when they have high self-efficacy in that area. Findings show adolescents' career choice and occupational level are tied to domains for which they have high self-efficacy, especially academic self-efficacy. These findings also reflected gender stereotypes in the careers (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001). Self-efficacy is more strongly related to task effort and persistence when the topic or skill is new, so when the topic is new and difficult students with high self-efficacy are more likely to persist (Schunk & Pajares, 2004). Findings also suggest students with high self-efficacy learn and achieve more even when ability levels are similar (Bandura, 1986; Pajares, 1996; Schunk, 1989; Valentine, DuBois, & Cooper, 2004; Zimmerman et al., 1992).

As a personal resource, especially for STEM minority students, self-efficacy has a profound impact on an individuals' ability to cope with challenges and problems (Gecas, 1989; Mirowsky & Ross, 1986; Taylor & Brown, 1988). Self-efficacy influences distress through coping behavior (Aneshensel, 1992) because "what people do or fail to do in dealing with their problems can make a difference to their well being" (Pearlin & Schooler, 1978, p.18). In coping with stress, self-efficacy makes instrumental, problem-solving behavior more likely than passive or avoidant behavior (Aneshensel, 1992; Chwalisz, Altmaier, & Russell, 1992; Thoits, 1995).

Much of the research focusing on the pursuit or avoidance of STEM course taking and STEM majors included the concept of self-efficacy (Lent, Brown, & Hackett, 1994, 2000). Findings indicate self-efficacy is related to STEM interests, goals, persistence and performance (Betz & Hackett, 1983; Gainor & Lent, 1998; Hackett, Betz, Casas, & Rocha-Singh, 1992; Lent, Brown, & Larkin, 1984, 1986; Lent, Lopez, & Bieschke, 1991). Although primarily researching with adult participants, the studies listed above found if a person did not have efficacy for an occupation they eliminated it from their considerations when choosing a career. Conversely, high self-efficacy for domain-specific academic and occupational requirements was related to more career options, greater interest in career options, better academic preparation for the career, and more persistence in challenging career goals. These effects were evidenced even when ability, prior achievement, and interests were controlled. Thus, self-efficacy has a strong, positive association with academic goals and, based on the work of Lent and colleagues (2003, 2005), it is expected to be associated with science and mathematics pathways and a subsequent STEM major acting as a buffer for STEM minority students.

Social Resources

Students have access to various forms of social support that can facilitate school success. Sociologist, James Coleman was one of the earliest users of the term “social capital” as a framework for examining sources of social influence on education and educational opportunities. Social capital refers to relationships an individual (or group of individuals) may have with resources or "social networks" providing access to opportunity (Coleman, 1988; Stanton-Salazar, 1997). While both Coleman and Stanton-Salazar describe social relationships both in and out of the family structure, Stanton-Salazar's definition of social capital includes "social antagonism" making access to social capital problematic for students of color (p. 3). Stanton-Salazar identifies two types of social networks impacting minority students' access to social capital: institutional agents (e.g., teachers) and protective agents (e.g., family members).

Parents and Teachers

Parents and teachers significantly contribute to a student’s social capital in the form of attitudes and expected outcomes at school (Frome & Eccles, 1998). In 1995, Singh, Bickley, Keith, Keith, Trivette, and Anderson explored the effects of different components of parental involvement on the achievement of eighth-graders. The study identified four components of parent involvement including: parental aspirations for the child’s education, parent-child communication about school, home-structure, and parental participation in school related activities. These four factors had little to no effect on achievement, except for parental aspirations. The study found that parental aspiration was as influential on student achievement as the influence of prior achievement. Parental aspiration was the factor that had the biggest impact on pupil achievement once social class factors had been taken into account.

In their work on achievement-related choices, Eccles and colleagues (1983) concluded parents' and teachers' expectations of and attitudes toward students' abilities significantly influence how students perceive their own ability in the formation of self-concept beliefs. Self-beliefs then impact educational choices. The role of gender-specific expectations and attitudes has been explored, and studies show that teachers' and parents' gender-stereotypic behavior and expectations can undermine girls' confidence in their mathematical abilities, eventually discouraging girls from choosing mathematics-related courses and fields of study (Eccles & Wigfield, 2002; Turner, Steward, & Lapan, 2004).

In an examination of engineering majors, parental influence is cited by Goodman and Cunningham (2002) as a major factor in female engineering students' career choice. Trenor, Yu, Waight, Zerda, and Sha (2008) supported this finding and further described the importance of family and school personnel in understanding the academic and career choices made by students of different genders and ethnicities.

Peers

Examining the effects of significant others in children's achievement has primarily focused on parents and teachers while often overlooking the role of peers. In the famous study completed nearly forty years ago, *Equality of Educational Opportunity,* Coleman (1966) studied the features of a school environment that lead to student academic differences. A key finding of the study was student achievement is linked to the educational backgrounds and goals of other students. Horn and Chen (1998) supported this finding in a study of high school students at-risk of dropping out. The study found students at moderate or high drop-out risk levels were nearly four times more likely to enroll in college if most of their friends were planning to attend a four-year college. Peer groups have also been found to play a role in mathematics and science course selections. Dryler (1999) found boys' and girls' choices of courses correlated with the choices of their same-sex classmates but not with the choices of their opposite-sex classmates.

Studies examining peer influence on academics have found moderate correlations between friends' report card grades and standardized test scores (Berndt & Keefe, 1995). In a 2003 study, Altermatt and Pomerantz found friends to be the most influential with regard to report card grades. Friends also influenced achievement-related beliefs such as: to what they attributed their academic successes; the importance of meeting academic standards; as well as preference for challenging coursework. Kindermann (1993) studied peer effects on classroom involvement and disruption of fourth- and fifth-grade students. Berndt and Keefe (1995) conducted a similar study with seventh- and eighth-grade students. The studies found students who perceived their peer group as being involved and nondisruptive at the beginning of the year became more involved and less disruptive during the year.

The mechanism of influence may also play a role in academic achievement. Studies suggest children and their friends may have similar achievement through two processes: (1) modeling and (2) active adoption of beliefs using discussion, promotion, and reinforcement (Berndt, Laychak & Park, 1990). Altermatt and Pomerantz (2003) found students did not develop academic beliefs by simply watching the actions of classmates, but their beliefs were shaped by the participating in conversations where the achievement beliefs were discussed.

Differences in Social Resources for Minority Students

The differences in the socialization of students may be a contributing factor to achievement differences and future academic orientation between racial groups. The examination of cultural similarities and differences between and among different ethnic-racial groups helps to paint a picture of effective support and buffering mechanisms for groups underrepresented in the math and sciences; however, when examining group differences in social factors, it is important to remember within group differences can be just as significant as between group differences. It is therefore important to take care with interpretation of findings to avoid overgeneralization.

Asian-American students. Asian-American students show strong academic performance. Goyette and Xie (1999) confirmed other theories that parental expectations play a major role in Asian-American students' successes. In addition to parental expectations, Asakawa and Csikszentmihalyi (2000) contribute academic success to the social orientation of Asian-American students. They found Asian-American adolescents are more socially oriented and find approval in group settings. Asian-American students are more likely to identify with and internalize the beliefs and values of significant others including the educational values of parents and peers.

African-American students. Ford and Thomas (1997) found the underachievement of minority students with above average abilities could be partially attributed to negative peer pressure. The phenomenon of academically successful African-American students criticized by their low-achieving peers for "acting white" has been documented (Forham & Ogbu, 1986). A recent study of Texas schools found having more black classmates slows the achievement gains of other black elementary school children, especially above-average students; however, racial composition had little effect on other racial groups (Hanushek, Kain, & Rivkin, 2002).

Additional studies document trends in the gender differences among African American students. In a study by Greene and Mickelson (2006), gender differences in achievement were not evidenced in African American second grade students; however, by eighth grade female students earned higher test scores than their male counterparts. The authors concluded this finding was due to differences in socialization with the achievement of male students most affected by personal attitudes about education, the school environment, and their peer group. Female African American academic achievement was most influenced by socioeconomic status and cultural capital. The authors further noted the trend in lower male achievement continued into high school.

To examine students' transition to high school, Roderick (2003) studied African American students in Chicago. Similar to Green and Mickelson's (2006) findings, from eighth to ninth grades, male students evidenced steeper declines in academic achievement than female students and teachers held more negative views of male students. The gender difference was dramatically represented by graduation rates with 80% of African American females graduating as compared to only 40% of males. When examining academic skill levels, the study found that even when males possess the appropriate academic skills, they often lack the self-efficacy beliefs and future goals that act as coping mechanisms when experiencing stress in academic and peer environments.

Hispanic/Latino students. Hispanic students seem to be affected by social resources differently. Conchas (2001) studied a California high school and found an "achievement hierarchy" among Hispanic students in which achievement levels separated students socially as well as academically. Conchas described a school in which U.S.-born Mexican-American students were often in remedial programs while first-generation and immigrant students were often in advanced programs. The high-achieving Hispanic students preferred not to associate with "remedial" students; therefore, Conchas believes low-achieving students lacked social encouragement to succeed.

In a mixed-methods study of career choice among undergraduate engineering majors, Trenor and colleagues (2008) found the roles parents played in career choice varied with parental education level and occupation with many White, African American, and Asian students reporting role-model and cultural expectations for pursuing engineering. The encouragement of school personnel to major in engineering was evident across all groups; however, the influence of teachers and counselors proved most important for Hispanic student as Hispanic students reported an overall lack of familial knowledge about the field of engineering.

Another interesting finding from Trenor's (2008) work was the cultural difference in parental expectations for sons and daughters. A first-generation Hispanic female described that "in the Hispanic culture daughters are expected to get married and have children and are not encouraged to 'be with people [the parents] don't know'" (Trenor et al., 2008, p.457). After her father took training classes at work he changed his attitude about her education.

Although just a sampling of research has been presented here reflecting the differences in social resources for females and ethnic-racial minorities, it is evident the cultural backgrounds of students and their families play an integral role in the type and amount of social support they receive. Understanding how minority status, efficacy beliefs, social resources, and school policy interact to impact academic preparation and subsequent STEM participation within a framework is the main goal of this study; and, prior research in these diverse areas may lead us to a model that spans disciplines, research on subcultures, and historical trends to add to the research on diversity in the STEM fields.

CHAPTER THREE

METHODOLOGY

Introduction

The purpose of this study is to test a proposed model of mathematics course taking and selection of a STEM field of study developed from social psychological literature linking social identity and self processes with academic decision making. The initial model tests the use of advanced mathematics course taking as a proxy to a college major in a STEM field. This study further develops a second model linking social identity and mathematics course taking using the nested structure of the data to consider the role of school grouping policies on course taking for the overall population as well as separately by racial group. African American and Latino students are underrepresented in the STEM disciplines, and collectively, these minority students often lack high school mathematics preparation; therefore, it is important to understand how the coping resources of self-efficacy, as well as the social resources of parent, teacher, and peer interaction work differently for students of different racial groups. This chapter presents the research methodology used to explore the proposed models and test the hypotheses of the study. The chapter describes the data used, scale development and measures, a description of the models and variables, procedure of a logistical structural equation model (SEM), procedure of a hierarchical linear model (HLM), and the procedures used to test the models.

Data

The Educational Longitudinal Study of 2002 (ELS:2002) is part of the National Education Longitudinal Studies Program of the National Center for Education Statistics (NCES). The most recent of four decades of longitudinal data, ELS began collecting data on 10th grade students in 2002 and follows the students through high school to postsecondary school and/or the workforce. In the high school years (2002 and 2004), ELS:2002 was an integrated multilevel survey including students, parents, teachers and schools. Approximately six months to one year after students completed high school, student transcripts were collected allowing for more complete high school records. In 2006, the second follow-up, student respondents were surveyed about their college experience, work-force participation, family life, and civic engagement. Future collection points have not yet been determined, but NCES anticipates following the students until they are 30 years of age.

Sampling

Beginning in 2002 with a nationally representative two-stage stratified probability sample, ELS:2002 began with a selection of schools by U.S. census division and location (private schools were oversampled). The final sample was comprised of 750 schools (a 68 percent participation rate). The second stage randomly selected sophomores from the schools identifying an eligible sample of over 17,000 students. Over 15,000 students participated with Asian students and students in private schools oversampled for a weighted response rate of 87%. In addition to returning to the base-year schools, the first follow-up contacted student respondents and nonrespondents regardless of whether they remained in the same school or transferred. Students, dropouts, homeschooled students, and early graduates comprised the 16,500 student sample. The second follow-up contacted students when most were 2 years past high school graduation, in the labor force and/or postsecondary education. For various reasons, some students were identified as out of scope permanently; however, of the sample members, 14,200 students completed the second follow-up interview through web-based self-administration, computer-assisted telephone, or face-to-face administration.

Weighting

ELS: 2002 includes weights for the three waves of data collection. In the base year, the weighting scheme compensated for unequal probabilities of selection of schools and students into the sample as well as for some schools and students in the sample not participating. After adjusting for nonresponse bias and poststratifying to known population totals, three sets of weights were computed: school weight, student completion weight, and a contextual weight for the expanded student sample including “questionnaire-ineligible” students. In the first follow-up three individual-level weights were generated: a cross-sectional weight, an expanded sample weight, and a panel weight for sophomore cohort students with data at time 1 and time 2. Additionally, a cross-sectional weight was computed for transcript respondents. For the second follow-up, four sets of weights were generated: a cross-sectional weight, a cross-sectional transcript weight, a second follow-up panel weight for students responding in first and second follow-up, and a second follow-up panel weight for students who were sophomores during the base year survey and responded to the second follow-up.

Scale Development and Variable Description

Scales

Based on existing literature, variables from the student questionnaire were selected for use in four scales: parent factor, peer factor, teacher factor, and mathematics self-efficacy. Principal Components Analysis reduced this large set of variables into a smaller number of components by extracting the maximum variance from the data set with each component (Tabachnick & Fidell, 2007). After extraction, a Varimax rotation aided in interpretation of the factors by maximizing the variance of the loadings within factors, across variables.

Kaiser’s criterion (1960) of retaining the components with eigenvalues greater than one, justified the retention of the hypothesized four components. After confirming the structure of the components, the Principle Components Analysis was performed separately for each of the four factors. Furthermore, to examine the internal consistency of the four scales Chronbach's alpha coefficients were calculated. The components, their items and factor loadings, and alpha coefficients are displayed in Table 1.

Table 1.

Factor Analyses for Scales

Scale and Items	Factor Loading	Eigenvalue	Explained Variance	Alpha Coefficient
Math Self-Efficacy		3.94	78.9%	.93
Can do an excellent job on math tests.	.87			
Can understand difficult math texts.	.88			
Can understand difficult math class.	.90			
Can do excellent job on math assignments.	.90			
Can master math class skills.	.89			
Parent factor		3.34	55.6%	.84
How often discussed:				
school courses with parents.	.78			
school activities with parents.	.77			
things studied in class with parents.	.77			
grades with parents.	.72			
prep for ACT/SAT with parents.	.67			
going to college with parents.	.75			
Peer factor		2.62	65.4%	.82
Important to friends:				
to attend classes regularly.	.82			
to study.	.82			
to get good grades.	.82			
to continue education past high school.	.77			
Teacher factor		2.46	49.1%	.73
The teaching is good.	.77			
Teachers are interested in students.	.81			
Teachers praise effort.	.69			
Teachers expect success in school.	.59			
Students get along well with teachers.	.63			

The first component of mathematics self-efficacy constructed with items measuring efficacy beliefs explains 78.9% of the variance and has an eigenvalue of 3.94. The second component called "Parent Factor" with an eigenvalue of 3.34 explains 55.6% of the variance and is heavily loaded by variables measuring the frequency of parent-child discussions about school.

The second component with an eigenvalue of 2.62 explains 65.4% of the variance; it includes four variables measuring the importance for peers to show specific academic behaviors. The final component called “Teacher Factor” has an eigenvalue of 2.46 and explains 49.1% of the variance. It is heavily loaded by items measuring teacher’s relationships with students. The reliability of the components is supported with each component being loaded heavily by four or more variables. All coefficients were above .73 showing acceptable internal consistency for the four scales.

Examining relationships among the scales provided validity evidence for self-concept and social factors. The correlation matrix in Table 2 shows the intercorrelations among the scales. To give evidence of discriminant validity, it is recommended correlations differ significantly from 1.0 (Widaman, 1985). Although statistically significant, all four correlations demonstrate measures of distinct constructs. Based on social capital research, a positive relationship was expected among the social resource variables of parent factor, peer factor, and teacher factor. All correlations were significant. Frequent parent-student discussion about academics positively correlates to a perceived high importance of academics in peers, higher ratings of the student-teacher relationship and high math self-efficacy. Students in this sample with high math self-efficacy also have parents focused on academics, academically-focused friends, and positive relationships with their teachers.

Table 2.

Intercorrelations among Scales

	Math self-efficacy	Parent Factor	Friend Factor	Teacher Factor
Math self-efficacy	1.00			
Parent Factor	.21	1.00		
Friend Factor	.17	.34	1.00	
Teacher Factor	.23	.27	.28	1.00

Variables

As discussed in the introductory chapter, the purpose of this study is to examine the relationships between mathematics self-concept and social relationship variables and how they mediate the effects of background variables and prior mathematics achievement on mathematics course taking and subsequent choice of a STEM major. Based on previous research it is expected mathematics course taking will act as a proxy for STEM major allowing for the examination of effects of school grouping practice on mathematics course taking in underrepresented racial groups. The analyses for the study are in two parts. The first set of analyses utilizes a logistic structural equation model (SEM) to better understand the relationships between variables of interest. The second set of analyses capitalizes on the data's nested structure of students within schools using hierarchical linear modeling (HLM) to understand the differential effects of school grouping policy on students' mathematics course taking. The latent variables for this study include the social relationships of parent factor, peer factor, and teacher factor as well as the construct of mathematics self-concept. Although the methods of analysis are discussed separately, some variables are used in both models; therefore, the variables are described collectively. Descriptive statistics are presented in Table 3.

Student/Family Demographics. ELS: 2002 used single imputation for missing questionnaire data for some demographic variables in the base year and the remaining missing values were imputed for the first follow-up. Therefore, the first follow-up demographic variables are more complete and are used in this study's analyses.

The independent variables of gender and race/ethnicity were used as females and racial minorities are underrepresented in STEM majors. In the ELS data, race is reported in one of seven categories: white, non-Hispanic; multiracial, non-Hispanic; Hispanic, no race specified; Hispanic, race specified; Asian, Hawaiian/Pacific Islander; American Indian/Alaskan Native; or Black/African American, non-Hispanic. For the SEM analyses and overall HLM model, race was recoded into: 0=white and Asian/Pacific Islander; and, 1=Black/African American and Hispanic. For separate HLM analyses, race was recoded into four categories: white, Black/African American, Asian/Hawaiian/Pacific Islander, and Hispanic. Sex was self-reported on the student questionnaire, with missing data imputed from school records (0=male, 1=female.).

The independent variable of SES composite was used as the measure of socio-economic status for the HLM analyses. The SES composite is derived using responses from the parent survey and is the mean of the non-missing standardized values of parents' occupation, parents' education, and family income. The SES composite is a standardized value with a mean of zero. For the SEM model examining the effects of structural location on math course taking and the pursuit of STEM major, the SES composite was recoded into two categories: 0=above average SES, and 1=below average SES for the purpose of capturing minority status. For the HLM analyses, the continuous SES composite was used to utilize the full variance of the SES variable.

Prior Math Achievement. The variable of prior mathematics achievement was the Item Response Theory (IRT) scale score in mathematics. The IRT scale scores for ELS:2002 represent estimates of the number of items a student would have answered correctly if they had taken all questions on a criterion-referenced mathematics achievement test administered in during the 10^{th} grade year in Spring 2002. The mathematics achievement test was designed to show student mastery of skills, knowledge and other cognitive behaviors related to mathematics. The IRT scale score separates each student's achievement and test characteristics from each other (i.e., difficulty and discrimination). Thus, the IRT scores represent comparatively genuine student achievement not contaminated by test characteristics at different times or under different test conditions (Hambleton, Swaminathan, & Rogers, 1991; McDonald, 1999). As prior achievement is a strong predictor of mathematics course taking, it is important to consider and control for mathematics achievement prior to 10^{th} grade to better understand the roles of social influence variables and mathematics self-concept in mathematics course taking.

Mathematics Self-concept. Mathematics self-concept is assessed by five items from the base year student questionnaire using a 4-point rating scale (from *almost never* to *almost always*). After the factor's structure was confirmed with Confirmatory Factor Analysis (CFA) in the SEM analyses, the items were standardized then averaged to create a standardized mean score for mathematics self-concept. Cronbach's alpha for the mathematics self-concept using the ELS: 2002 data was .93.

Parent factor. Assessed by six items for which students self-reported the frequency of discussions with parents about academic topics such as their courses and going to college. The times used a 3-point rating scale from *never* to *often*. Cronbach's alpha for parent factor was .84, with items showing internal consistency. After CFA, they were standardized then averaged for a standardized mean score.

Peer factor. The four items were standardized and averaged after CFA for a mean composite score for peer factor were self-report items from the base year survey. Students were asked to rate the perceived importance of attending class, studying, good grades, and continuing education of their friends on a 3-point scale from *not important* to *very important.*

Teacher factor. Teacher factor is comprised of five items from the base year student questionnaire using a 4-point rating scale from *strongly disagree* to *strongly agree*. The items asked students to report on perceived teaching quality and teacher behavior. Items were standardized then averaged for a standardized mean score after evidence in CFA supported the construction of a composite variable.

Mathematics course taking. The highest math course taken in high school, taken from the student transcripts, indicates the highest level of math for which the student received high school credit. Also called a "pipeline measure", it was originally created by Burkam and Lee (2003). Using transcript data from NELS:88, the authors assigned high school courses (to one of four levels based on their Classification of Secondary School Courses (CSSC) codes and a description of course content: nonacademic math courses, low academic math courses, middle academic math courses, and advanced academic math courses. This measure was expanded for ELS: 2002 transcript data to include 8-levels: (1) no math; (2) nonacademic math (basic mathematics, consumer mathematics); (3) low academic math (pre-algebra); (4) middle academic math I (algebra I and geometry); (5) middle academic math II (algebra II); (6) advanced math I (trigonometry, analytical geometry, statistics); (7) advanced math II (pre-calculus); and (8) advanced math III (calculus) (Bozick & Lauff, 2007). This study examines the impact of higher mathematics course taking. Previous STEM pipeline research indicates Algebra II as a minimum high school mathematics course predicting choice of STEM major. Therefore, the three lowest levels (no math, nonacademic math, and low academic math) are considered to be well below the prerequisite math course taking needed for matriculation in a STEM field.

STEM major. Student major was an item from the second follow-up year for which students reported their major category. The "major in 2006, 2-digit code" was recoded to create a binary variable: STEM major (STEM =1; no STEM=0). The following two-digit codes were recoded as (1) STEM major: (05) Biological and Biomedical sciences; (08) Computer/information sciences/support tech; (11) Engineering technologies/technicians; (18) Mathematics and statistics; (25) Physical sciences; and, (28) Science technologies/technician. All other codes as well as *survey component legitimate skip* and *item legitimate skip* were coded as (0) no STEM major. The legitimate skips were included as no STEM major because the follow-up student interview was constructed with skip patterns so if a respondent did not attend postsecondary school or if a major was undeclared the question was not asked. Although the respondent did not have the opportunity to answer the question, with a legitimate skip I assume the respondent was not enrolled as a STEM major as they neither attended a postsecondary school nor declared a major. Survey *missing* and *nonrespondent* were coded as missing.

Table 3.
Means, Standard Deviations, and Descriptives for Variables (weighted using Second follow-up base year panel weight).

Name of Variable	Denoted	Item Wording and Codes	M	SD
Social Structure				
SES	SES	First Follow-up SES composite [recoded for SEM (1=below average SES, 0=above average SES)]	.49	.50
Gender (female)	FEMALE	First Follow-up Sex Composite recoded (0=male, 1=female)	.53	.50
Ethnicity: African American/Hispanic	RACE	First Follow-up race/ethnicity composite recoded (0=white and Asian/Pacific Islander, 1=African American and Hispanic)	.24	.43
Prior Mathematics Achievement				
10^{th} grade math Achievement score	ACH	Math IRT estimated number right (10^{th} grade)	39.63	11.80
Coping Resources				
Social				
Teacher Factor	T1	The teaching is good.	2.92	.63
α=.73	T2	Teachers are interested in students	2.86	.68
	T3	Teachers praise effort.	2.74	.76
	T4	Teachers expect success in school.	2.67	.81
	T5	Students get along well with teachers.	2.79	.57
		(1=strongly disagree to 4=strongly agree)		
Parent Factor		How often discussed		
α = .84	P1	school courses with parents.	2.13	.67
	P2	school activities with parents.	2.19	.71
	P3	things studied in class with parents.	2.12	.66
	P4	grades with parents.	2.43	.61
	P5	prep for ACT/SAT with parents.	1.73	.72
	P6	going to college with parents.	2.33	.67
		(1=never to 3=often)		
Peer Factor		Important to friends		
α=.83	F1	to attend classes regularly.	2.48	.59
	F2	to study.	2.23	.62
	F3	to get good grades.	2.45	.59
	F4	to continue education past high school.	2.53	.60
		(1=not important to 3=very important)		
Personal				
Math self-efficacy	S1	Can do an excellent job on math tests.	2.57	.92
α=.93	S2	Can understand difficult math texts.	2.38	.94
	S3	Can understand difficult math class.	2.49	.95
	S4	Can do excellent job on math assignments.	2.65	.93
	S5	Can master math class skills.	2.68	.93
		(1=almost never to 4=almost always)		

Table 3, continued.

Means, Standard Deviations, and Descriptive Statistics for Variables (weighted using Second follow-up base year panel weight).

Name of Variable	Denoted	Item Wording and Codes	M	SD
Outcomes				
Highest math course	COURS	Highest level of math from transcript data (1) no math; (2) nonacademic math (basic mathematics, consumer mathematics); (3) low academic math (pre-algebra); (4) middle academic math I (algebra I and geometry); (5) middle academic math II (algebra II); (6) advanced math I (trigonometry, analytical geometry, statistics); (7) advanced math II (pre-calculus); and (8) advanced math III (calculus)	5.56	1.59
STEM major	STEM	Student declared STEM major 2 years after high school (0=no STEM major, 1=STEM major)	.09	.28

School policy—Ability grouping. The school policy of student access to courses comes from a question on the administrator's questionnaire asking about the school's approach to providing instruction in the core curriculum for students with "different abilities, learning rates, interests or motivations" not including Special Education programs. Principals could choose one of three possible approaches: (1) We offer differentiated courses in our core curriculum but students have open access to any course provided they have taken the required prerequisites; (2) We offer differentiated courses and do differentiated grouping in our core curriculum; or (3) We offer a variety of undifferentiated courses in our core curriculum and students have open access to any course provided. The tracking literature defines differentiated courses as courses grouped by ability or achievement. From the above choices I assume a school reporting approach 3 does not have a tracking/grouping policy, while approach 1 is a grouping policy but with some student choice, although the choice is limited by prerequisites. Approach 2 appears to be the most traditional representation of tracking/grouping without student choice. School approaches to core curriculum instruction were dummy coded with approach 3 (no differentiation and student choice) used as the reference group. I am comparing the two approaches to ability grouping to the least restrictive practice for addressing students with different abilities. The ability grouping variable is used as main predictor variable at the school level in the hierarchical linear model (HLM) analyses to better understand the differential effects of student access to courses on mathematics course taking for underrepresented minorities.

Procedures

Structural Equation Modeling (SEM)

The purpose for modeling data in this study is to describe the structure of a nationally representative data set that follows students from early high school into postsecondary school and/or the workforce using a social psychological framework. The model represented in Figure 2 specifies the hypothesized relationships between variables. SEM estimates regressions among the continuous latent variables (Bollen, 1989; Joreskog & Sorbom, 1979). SEM has two parts: a measurement model and a structural model. The measurement model for SEM is a multivariate regression model that describes the relationships between observed dependent variables (factor indicators) and continuous latent variables (factors). The structural model uses one set of multivariate regression equations to describe the relationships among factors, the relationships among observed variables, and the relationships between factors and observed variables that are not factor indicators (Muthen, & Muthen, 1998-2004). Based on findings from social psychological literature, stereotype threat research, and the underrepresentation of females, African Americans and Hispanics in STEM fields, the three related sets of hypotheses are tested:

Hypotheses about Relationships between Structural Location and Coping Resources

1. Locations in social structures (female, African American/Hispanic, and low SES) are related to student personal resources to cope with stressors or threats measured by mathematics self-

efficacy. These relationships are direct as well as indirect, mediated by prior math achievement.

a. Gender (female) is related to math self-efficacy demonstrated by higher levels of mathematics achievement, but lower levels of math self-efficacy.
b. Race (African American/Hispanic) is related to math self-efficacy demonstrated by lower levels of math achievement and lower levels of math self-efficacy.
c. SES (below average) is related to lower levels of math achievement and lower levels of math self-efficacy.

2. Locations in social structures are related to measures of social resources as measured by the parent, peer, and teacher factors. Specifically:

a. Gender (female) is related to social resources as demonstrated in higher levels of parent, peer, and teacher academic focus.
b. Race (African American/Hispanic) is related to social resources as demonstrated in lower parent, peer, and teacher academic focus.
c. SES (below average) is related to social resources as demonstrated in lower levels of parent, peer and teacher academic focus.

Hypotheses about Relationships among Personal Resources and Social Resources

3. Social resources are related to personal resources. Social resources facilitate math self-efficacy.

a. Parents' academic focus is positively related to math self-efficacy.
b. A higher peer academic focus is related to higher math self-efficacy.
c. Measures of teacher as a social resource are related to lower math self-efficacy.

Hypotheses about Relationships among Structural Location, Coping Resources, and Educational Outcomes

4. Higher level math course taking in high school (math pipeline) is positively related to declaration of a STEM major in college.

5. Measures of social and personal resources are related to identification with STEM disciplines as evidenced by higher level math courses and enrollment in a STEM major. Specifically,

a. Parents' academic focus is positively related to the math pipeline.
b. A higher peer academic focus is related to a higher level in the math pipeline.
c. A higher teacher factor is negatively related to the math pipeline measure.
d. Mathematics self-efficacy is positively related to the math pipeline and declaration of a STEM major.

6. Structural locations are related, independently of coping resources, to STEM identification.

a. Gender (female) is negatively related to STEM identification as demonstrated in a lower level in the math pipeline and reduced likelihood of choosing a STEM major.
b. Race (African American/Hispanic) is related to outcomes as demonstrated in lower math pipeline and STEM majors.
c. SES (below average) is negatively related to STEM identification as evidenced by lower pipeline level and reduced likelihood of STEM major.

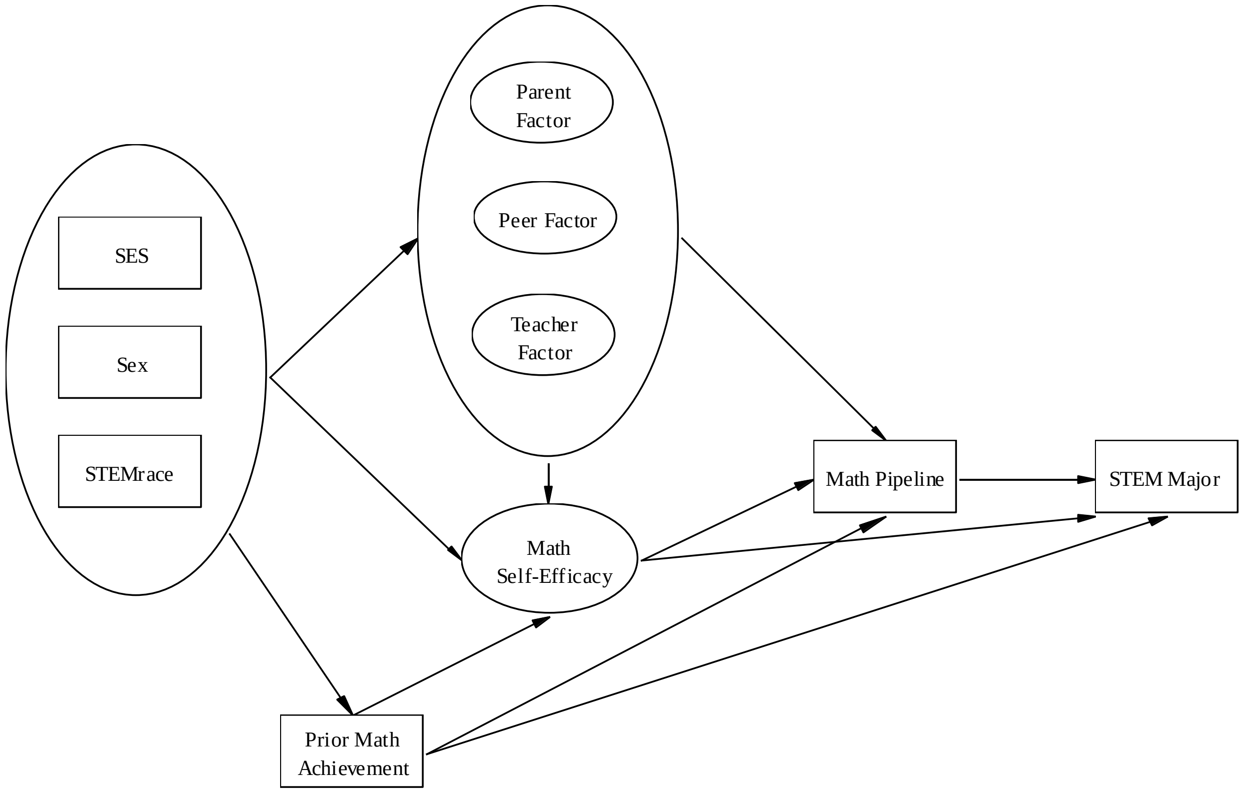

Figure 2. Hypothesized relationships among variables.

Structural Equation models, including the measurement and structural models, are estimated using Mplus statistical software. Mplus (Muthen & Muthen, 1998-2004) provides flexibility in model specification, analyzing models for observed variables that are binary, ordinal, nominal as well as continuous as are present in this study. Relationships among and between factors and observed variables for dependent variable factors (e.g. social and personal resources) are described by a set of linear regression equations while relationships for binary (STEM major) or ordered categorical observed (math pipeline) are described by a set of probit or logistic regression equations. With Mplus this study utilizes maximum likelihood estimation to test the measurement and structural model. Mplus provides robust estimation of standard errors and robust chi-square tests of model fit taking into account non-normality of outcomes (Muthen & Muthen, 1998-2004).

Hierarchical Linear Modeling (HLM)

Multilevel modeling with hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) was the analytic tool selected to test for associations between school policy on ability grouping and the social and personal resources. A two-level Hierarchical Linear Model is used to analyze effects of social and personal resources on higher level mathematics course taking as well as the role race plays in these social interactions. The structure of the data—student relationships and behaviors nested within schools—lends itself to multilevel models, which separate within- and between-unit sources of variability.

First, the fully unconditional model, a model with no predictors specified, is analyzed to justify the use of multilevel analyses. An estimate of the intra-class correlation is calculated to determine the proportion of the variance in the outcome that is between level-2 units (Raudenbush & Bryk, 2002). For this study, the fully unconditional model estimates mathematics course-taking for each student as a function of the school average course-taking plus random error with the school's mean course-taking varying randomly around a grand mean for all schools. Additionally, the model establishes a baseline value for the fit index (deviance score).

The fully unconditional model and intra-class correlation coefficient is shown by the equations below.

Level 1 (student level)

$$Math_{ij} = \beta_{0j} + r_{ij}\,.$$

where

$Math_{ij}$ represents the math course-taking of each student *i* in school *j*.

β_{0j} represents the school mean math course-taking of school *j*.

r_{ij} represents the random error of student *i* in school *j*.

i = 1, 2, 3, . . ., n*j* students in school *j*.
j = 1,2, ...J schools.

Level 2 (school level)

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

where
γ_{00} represents the grand mean math course-taking for all schools.
u_{0j} represents the random school effect, the deviation of school *j*'s mean from the grand mean.

Intra-class correlation coefficient

$$\rho = \tau_{00} / (\tau_{00} + \sigma^2)$$

where
τ_{00} represents variability in math course-taking between schools
σ^2 represents the within-school variability in math course-taking

Next, the conditional model is analyzed to determine model fit for the overall data. The equations presented below capture the hypothesized model based on prior literature examining predictors of mathematics course taking. As it is possible not all predictors or effects will be significant, in order to get parsimonious results, the conditional models will be built using model specification procedures suggested by Raudenbush and Bryk (2002): (1) at level 1, specify one variable at a time adding each predictor after all others are removed to avoid collinearity; (2) specify all level 2 predictors and check significance levels, remove insignificant effects from the slopes and then the intercepts, use deviance difference test to evaluate the model changes.

In the hypothesized model, the first level analyzes the contribution of the explanatory variables of SES, Sex, Parent Factor, Friend Factor, Teacher Factor, and Math Self-Efficacy to course taking at the individual level. The second level examines the effects of school course enrollment policy on mathematics course taking and assesses whether the slopes of the explanatory variables have significant variance components between schools. In level 2, it is hypothesized there will be interaction effects of school policy with all variables except parent factor.

Level 1

$$Math_{ij} = \beta_{0j} + \beta_{1j}SES + \beta_{2j}SEX + \beta_{3j}STEMrace + \beta_{4j}MathAch + \beta_{5j}Parent + \beta_{6j}Friend + \beta_{7j}Teacher + \beta_{8j}SelfEfficacy + r_{ij}$$

Where $Math_{ij}$ is the dependent variable; β_{0j} is the intercept; β_{1j} is a coefficient for the effect of social class on math course-taking; *SES* is the first follow-up SES composite; β_{2j} is a coefficient for the effect of gender on math course-taking, represented by the difference from the reference group (males); *SEX* is the first follow-up sex composite recoded (0=male, 1=female) β_{3j} is a coefficient for the effect of the minority race (Latino/African American) in STEM fields; STEMrace is the race composite recoded (0=White/Asian, 1=Latino/African American); β_{4j} is a coefficient for the effect of math prior achievement on course taking; *MathAch* is the Item Response Theory (IRT) scale score in 10^{th} grade mathematics. β_{5j} is a coefficient for the effect of parent-student academic discussions on math course-taking; *Parent* is the standardized mean score of six items measuring the frequency of discussions with parents about academic topics; β_{6j} is a coefficient for the effect of school importance to friends on course-taking; *Friends* is the standardized mean score of four items measuring perceived importance of attending class, studying, good grades, and continuing education to their friends; β_{7j} is a coefficient for the effect of student-teacher relationship on course-taking; *Teacher* is the standardized mean score of five items measuring perceived teaching quality and teacher behavior; β_{8j} is a coefficient for the effect of student math self-efficacy on math course-taking; *SelfEfficacy* is the standardized mean score for mathematics self-concept comprised of five items measuring students' efficacy beliefs in the math; and r_{ij} is a random component.

Level 2

$$\beta_{0j} = \gamma_{00} + \gamma_{01}NOCHOICE + \mu_{0j},$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}NOCHOICE + \mu_{1j},$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}NOCHOICE + \mu_{2j},$$

$$\beta_{3j} = \gamma_{30} + \gamma_{31}NOCHOICE + \mu_{3j},$$

$$\beta_{4j} = \gamma_{40} + \gamma_{41}NOCHOICE + \mu_{4j},$$

$$\beta_{5j} = \gamma_{50} + \gamma_{51}NOCHOICE + \mu_{5j},$$

$$\beta_{6j} = \gamma_{60},$$

$$\beta_{7j} = \gamma_{70} + \gamma_{71} NOCHOICE + \mu_{7j}, \text{ and}$$

$$\beta_{8j} = \gamma_{80} + \gamma_{81} NOCHOICE + \mu_{8j}.$$

Where *NOCHOICE* is a dummy code representing schools that offer differentiated courses with differentiated grouping without open enrollment; γ_{00} is the mean math course-taking for schools with no student choice of classes, γ_{01} is the mean course-taking difference between schools with no student choice schools and schools with open enrollment, γ_{02} is the mean course-taking difference between schools with no choice and the reference schools, u_{0j} is the unique effect of school *j* on mean course-taking holding school policy constant; $\gamma_{10} - \gamma_{60}, \gamma_{70} - \gamma_{80}$ are the average slopes in the reference schools (open enrollment), $\gamma_{11} - \gamma_{51}, \gamma_{71} - \gamma_{81}$ are the mean differences in slopes between schools without choice and the reference schools, and $\mu_{1j} - \mu_{5j}, \mu_{7j} - \mu_{8j}$ are the unique effects of school *j* on the corresponding coefficient-math course-taking slope holding school policy constant.

Following the specification procedures discussed above (Raudenbush & Bryk, 2002), the fixed regression coefficients are analyzed. To assess the contribution of each individual level explanatory variable, a model is analyzed with all of the level 1 explanatory variables fixed and the corresponding variance components of the slopes fixed to zero. Using Full Maximum Likelihood (FML) estimation, the improvement of the final model is assessed by computing the difference of the deviance of this model and fully unconditional model. To examine whether school grouping policy explains between school variations in mathematics course taking, FML estimation formally tests the improvement of fit.

The slopes of the explanatory variables are tested to assess if there is a significant variance component between the groups. Initially all variance components are included in the model and the chi-square test based on deviance was used to test model fit. Data-driven decisions are made to eliminate random components on a variable-by-variable basis. If the removal of a slope results in a significant decrease in model fit, the slope is included in the model although the variance component is insignificant.

As the socialization differences may be a contributing factor to variations in achievement and future academic orientation between racial groups, I am interested in the following questions: Are students of different races showing the same pattern of course taking regardless of school policy on student choice of courses? Do personal and social coping resources have different effects for students of different races? The examination of possible cultural similarities and differences between ethnic-racial groups on the parent, friend, and teacher factors may elucidate effective support and buffering mechanisms for racial groups underrepresented in math and science; therefore, after the model is analyzed for overall fit, the data is separated into four data sets based on race with removal of the *STEMrace* variable that was used to capture minority status in the overall model. For interpretation purposes, the model of fixed effects is held constant for all four racial groups. This makes it possible to compare coefficients between racial groups to determine if relationships between social and personal resource variables and course taking vary based on the race of the student. Testing of random slope variation is done for each of the four models with insignificant variance slope components fixed to zero if the result does not significantly impact model fit. This series of analyses results in four final models with the same fixed effects and different variance components for the slope.

Using the SEM and HLM methods described, I am examining the relationships between mathematics self-concept and social relationship variables and how they mediate the effects of background variables and prior mathematics achievement on mathematics course taking and subsequent choice of a STEM major. Furthermore, I anticipate the results of analyses to provide more information on the impact of school course enrollment policies on the mathematical preparation of high school students, specifically those traditionally underrepresented in STEM fields.

CHAPTER FOUR

ANALYSES AND RESULTS

For the purpose of presenting the results for the proposed models and corresponding hypotheses, this chapter discusses the sequential, analytical decisions made throughout the analyses. First, descriptive statistics and correlations for the study's variables are presented. Then, the structural equation modeling analyses (SEM) including results of the measurement and structural models are discussed. Finally, the results of the hierarchical linear model (HLM) are presented.

Data Preparation

ELS:2002 is a nationally-representative survey comprised of 750 schools in the first wave of data collection and the survey effort followed students collecting data for three waves thus far (through 2 years past high school). ELS: 2002 includes weights for the three waves of data collection. For the SEM analyses, variables from the base year, first follow-up, and second follow-up are used; therefore, the second follow-up panel weight was applied (F2PNLWT). For the HLM analyses, the first follow-up weight was used (F1PNLWT) as the STEM major variable was not included, and only variables from the base year and first follow-up were used.

With models spanning multiple waves of data, missing data are a concern. Especially in SEM analyses, listwise deletion (LD) eliminates cases where there is any data value missing. Unfortunately, with the use of multiple indicator variables as well as observed independent and dependent variables, LD discards other information a respondent has provided and reduces the sample size significantly. Additionally, LD has been shown to produce biased parameter estimates, increases in error variances for Likert data, and ill-conditioned covariance matrices (Kline, 2005). To address this problem, the LISREL 8.8 computer program (Jöreskog

& Sörbom, 2006) uses a multistage process to reach final estimates for data imputation. Starting values are generated with an expectation-maximization (EM) algorithm that estimates the moments based on the data and then estimates the data based on the moments with this process continuing iteratively until convergence. After generating the starting values, full information maximum likelihood (FIML) procedures to reach final estimates using Markov Chain Monte Carlo (MCMC) simulation, which generates populations of potential values. LISREL data imputation procedures were employed to produce a final data set used in model analyses.

Results

Descriptive Statistics

Background Variables

Correlations, mean scores, and standard deviations are displayed in Table 4. Examining the background variables of socioeconomic status, gender, underrepresented race, and prior math achievement, being African American or Hispanic correlates positively with low SES ($r = .24$). When considering the relationships between background variables and prior achievement, groups traditionally underrepresented in STEM fields, low SES ($r = -.35$), females ($r = -.10$), and African American and Hispanic ($r = -.36$), show significant negative correlations with 10th grade mathematics achievement.

The correlations between the background variables and course taking and STEM major were as expected. Higher mathematics prior achievement correlates highly ($r = .59$) with higher level mathematics course taking and moderately with choice of STEM major ($r = .36$). Low SES and mathematics course taking ($r = -.33$) as well as STEM major ($r = -.12$) show significant negative correlations with students from below average socioeconomic backgrounds less likely to finish high school with higher level math courses and these students are less likely to pursue

Table 4

Mean, Standard Deviation, and Correlation Matrix for Model Variables
(weighted using Second follow-up base year panel weight, missing values imputed using LISREL)

	SES	FEMALE	RACE	ACH	T1	T2	T3	T4	T5	P1	P2	P3	P4	P5	P6
SES	1.00														
FEMALE	0.02	1.00													
RACE	0.24	0.02	1.00												
ACH	-0.35	-0.10	-0.36	1.00											
T1	-0.05	0.04	-0.02	0.12	1.00										
T2	-0.05	0.03	-0.04	0.11	0.67	1.00									
T3	-0.02	0.05	0.02	0.07	0.46	0.57	1.00								
T4	0.03	0.08	0.10	-0.01	0.40	0.41	0.36	1.00							
T5	-0.10	0.01	-0.11	0.18	0.49	0.49	0.35	0.30	1.00						
P1	-0.17	0.10	-0.07	0.15	0.15	0.15	0.14	0.18	0.13	1.00					
P2	-0.18	0.11	-0.07	0.17	0.16	0.16	0.16	0.19	0.16	0.69	1.00				
P3	-0.16	0.10	-0.06	0.10	0.18	0.20	0.20	0.23	0.17	0.65	0.64	1.00			
P4	-0.13	0.10	-0.04	0.15	0.17	0.19	0.19	0.21	0.16	0.54	0.50	0.62	1.00		
P5	-0.16	0.06	0.03	0.11	0.13	0.16	0.17	0.26	0.16	0.50	0.46	0.49	0.43	1.00	
P6	-0.14	0.12	0.04	0.16	0.19	0.17	0.18	0.23	0.14	0.57	0.56	0.55	0.64	0.60	1.00
F1	-0.07	0.12	-0.03	0.18	0.30	0.27	0.23	0.31	0.28	0.26	0.31	0.28	0.38	0.28	0.33
F2	-0.04	0.15	0.04	0.00	0.21	0.21	0.21	0.27	0.18	0.21	0.24	0.28	0.26	0.26	0.25
F3	-0.04	0.11	0.05	0.09	0.23	0.24	0.22	0.32	0.21	0.24	0.28	0.27	0.37	0.29	0.36
F4	-0.13	0.12	0.00	0.14	0.22	0.25	0.22	0.31	0.21	0.25	0.30	0.26	0.33	0.34	0.39
S1	-0.09	-0.16	-0.03	0.42	0.23	0.20	0.22	0.16	0.19	0.19	0.19	0.18	0.22	0.22	0.24
S2	-0.09	-0.20	-0.02	0.37	0.17	0.16	0.17	0.14	0.17	0.16	0.16	0.14	0.16	0.21	0.18
S3	-0.07	-0.15	0.02	0.35	0.21	0.18	0.19	0.19	0.16	0.19	0.18	0.18	0.19	0.25	0.22
S4	-0.10	-0.12	-0.02	0.39	0.23	0.21	0.22	0.19	0.19	0.21	0.21	0.20	0.22	0.25	0.25
S5	-0.12	-0.12	0.00	0.39	0.24	0.22	0.22	0.19	0.21	0.21	0.21	0.21	0.24	0.27	0.28
COURS	-0.33	0.03	-0.19	0.59	0.14	0.14	0.09	0.08	0.18	0.18	0.23	0.15	0.20	0.23	0.24
STEM	-0.12	-0.09	-0.03	0.36	0.09	0.07	0.02	0.05	0.10	0.14	0.09	0.05	0.08	0.17	0.14
MEAN	0.49	0.53	0.24	39.63	2.92	2.86	2.74	2.67	2.79	2.13	2.19	2.12	2.43	1.73	2.33
SD	0.50	0.50	0.43	11.80	0.63	0.68	0.76	0.81	0.57	0.67	0.71	0.66	0.61	0.72	0.67

N=13980.

Table 4 (continued).

Mean, Standard Deviation, and Correlation Matrix for Model Variables (weighted using Second follow-up base year panel weight, missing values imputed using LISREL)

	F1	*F2*	*F3*	*F4*	*S1*	*S2*	*S3*	*S4*	*S5*	*COURS*	*STEM*
F1	1.00										
F2	0.74	1.00									
F3	0.74	0.70	1.00								
F4	0.71	0.61	0.73	1.00							
S1	0.26	0.14	0.21	0.21	1.00						
S2	0.21	0.14	0.18	0.18	0.84	1.00					
S3	0.25	0.19	0.23	0.23	0.79	0.83	1.00				
S4	0.28	0.20	0.27	0.26	0.82	0.77	0.84	1.00			
S5	0.27	0.19	0.25	0.25	0.80	0.77	0.84	0.87	1.00		
COURS	0.28	0.11	0.21	0.27	0.37	0.33	0.34	0.38	0.35	1.00	
STEM	0.18	0.10	0.10	0.09	0.29	0.30	0.31	0.34	0.34	0.50	1.00
MEAN	2.48	2.23	2.45	2.53	2.57	2.38	2.49	2.65	2.68	5.56	0.09
SD	0.59	0.62	0.59	0.60	0.92	0.94	0.95	0.93	0.93	1.59	0.28

N=13980.

degrees in STEM majors. In fact, low SES correlates negatively with all of the indicator and outcome variables specified in this study.

Being female correlates positively with mathematics course taking ($r = .03$), but negatively with STEM major ($r = -.09$). However, unlike low SES students, being female correlates positively with the social support indicator variables. Females report: more agreement with the student-teacher relationship items (ranging from $r = .01$ to $r = .08$); more frequent academic conversations with parents (ranging from $r = .06$ to $r = .12$); and, academic behaviors of friends are important (ranging from $r = .11$ to $r = .15$). The math self-efficacy items do not show the same pattern of response. Being female correlates negatively with the five self-efficacy indicator items with correlations ranging from $r = -.12$ to $r = -.20$. Therefore, females are taking higher level mathematics courses and self-report more positively on the social resource items; however, females report lower math efficacy and are less likely to enroll in a STEM major two years after high school.

Examining the relationship of course taking and STEM major with being African American or Hispanic, students from these underrepresented groups are less likely to take higher level mathematics courses ($r = -.19$) and less likely to declare a STEM major two years after high school ($r = -.03$). When considering the relationships between underrepresented race and items indicating the coping resources of social support and mathematics self efficacy, the correlations do not indicate a consistent pattern. For the items indicating the student-teacher relationship, three items show negative correlations: “the teaching is good” ($r = -.02$), “teachers are interested in students” ($r = -.04$), and “students get along well with teachers” ($r = -.11$). The items “teachers praise effort” ($r = .02$) and “teachers expect success in school” ($r = .10$) correlate positively with being African American or Hispanic. For items indicating the frequency of academic discussions with parents, four items show negative correlations: “how often discussed school courses with parents” ($r = -.07$), “how often discusses school activities with parents” ($r = -.07$), “how often discussed things studied in class with parents” ($r = -.06$), and “how often discussed grades with parents” ($r = -.04$). Two items, “how often discussed prep for ACT/SAT with parents” ($r = .03$) and “how often discussed going to college with parents” ($r = .04$) correlate positively with underrepresented race. Examining the correlations between peer factor indicator items, there is a negative correlation between underrepresented race and “important to friends to attend classes regularly” ($r = -.03$), while the items “important to friends to study” ($r = .04$) and “important to friends to get good grades” ($r = .05$) correlate positively with underrepresented race. The correlation between being African American or Hispanic and “important to friends to continue education past high school” is insignificant. The correlations with self-efficacy items are similarly inconsistent. Three items show negative correlations with underrepresented race: “can do an excellent job on math tests” ($r = -.03$), “can understand difficult math texts” ($r = -.02$), and “can do an excellent job on math assignments” ($r = -.02$). The item “can understand a difficult math class” correlates positively with being African American or Hispanic ($r = .02$), while the item “can master math class skills” was not significantly correlated with race.

The correlations between prior math achievement and mathematics course taking ($r = .59$) and choice of a STEM major ($r = .36$) are large and positive. Students with higher math scores in 10th grade take more difficult math courses in high school and are more likely to declare a STEM major two years after leaving high school. When examining the relationship between prior achievement and the student-teacher relationship indicator items, all items show a significant positive correlation with achievement (ranging from $r = .07$ to $r = .18$) except for “teachers expect success in school” ($r = -.01$) which shows a weak, negative correlation. Frequency of academic discussions with parents corresponded positively with prior achievement with correlations ranging from .10 to .17. Tenth grade math achievement also correlated significantly in a positive direction with three of the four items asking students about the importance of academics to friends, with correlations ranging from .09 to .18, the only item not significant was “important to friends to study”. Prior math achievement relates most strongly with the items indicating the coping resource of mathematics self-efficacy (ranging from $r = .35$ to $r = .42$). Students with the higher prior math achievement, as measured by the 10th grade achievement test, report more confidence in their abilities on math tasks.

Although all but three of the correlations between the background variables and the indicator and outcome variables are significant at the .01 level, it is important to note only a few of the correlations were above an absolute value of .20. Focusing on the strongest correlations, Low SES is strongly correlated with underrepresented race, lower mathematics achievement and lower level course taking. Being female is strongly correlated with lower self efficacy, specifically the item “can understand difficult math texts”. Being African American or Hispanic was strongly correlated with lower mathematics achievement, while 10th grade mathematics achievement was strongly correlated with all of the self-efficacy indicators as well as math course taking and declaration of a STEM major.

Coping Resources

Teacher factor. Measured by student self-report items (T1-T5) indicating agreement with aspects of the student-teacher relationship, the teacher factor was specified to capture the social capital gained by the student from supportive student-teacher relationships at school. Students generally agree that “teaching is good” ($\bar{X} = 2.92$), “teachers are interested in students ($\bar{X} = 2.86$), “teachers praise effort” ($\bar{X} = 2.74$), “teachers expect success in school” ($\bar{X} = 2.67$), and “students get along well with teachers” ($\bar{X} = 2.79$) which approach a rating of 3 “agree” on the response scale for these items. The correlations among the student-teacher relationship items are significant and positive with the strongest correlation ($r = .67$) shown for “teaching is good” with “teachers are interested in students”. All other correlations are moderate (ranging from $r = .35$ to $r = .57$). The weakest correlation ($r = .30$) was “teachers expect success in school” with “students get along well with teachers”. It is possible this correlation is affected by the pattern evidenced by students in the underrepresented racial groups on these questions.

Parent factor. The six items related to frequency of academic discussions with parents (P1-P6) show moderate to high correlations ranging from .43 to .69. Items P1 through P3, “how often discussed school courses with parents", "how often discussed school activities with parents", and "how often discussed things studied in class with parents" show the highest correlations ($r = .64$ to $r = .69$) with "how often discussed prep for the ACT/SAT with parents" correlating only moderately with discussing school activities ($r = .46$), things studied in class ($r = .49$), and grades ($r = .43$). The item means are close to 2 corresponding with a rating of sometimes; however, the means range from 1.73 for discussing prep for the ACT/SAT to 2.43 for discussing grades showing students report discussing grades more frequently with their parents than they discuss preparing for college admissions tests.

When examining the relationship of the items with mathematics courses studied, overall frequency of parent-child discussions about academics correlates more strongly (from $r = .15$ to $r = .24$) than the student-teacher relationship (from $r = .09$ to $r = .18$) with frequency of discussions with parents about school activities ($r = .23$), prep for ACT/SAT ($r = .23$), and going to college ($r = .24$) showing the strongest relationship with high school mathematics course taking. Although the strength of the relationships is weaker for STEM major, all parent items correlate positively with STEM major with frequency of discussions about school courses ($r = .14$), prep for the ACT/SAT ($r = .17$), and going to college ($r = .14$) showing the largest correlations. It is possible that discussions with parents involving courses, preparation for college admission tests, and going to college have more of a long-term impact on course taking and declaration of major as these discussions are considering future academic decisions rather than the more immediate impact of current studies and grades.

Peer factor. The four items measuring importance of academics to friends (F1-F4) show high correlations ranging from .61 to .74, with all four items showing mean scores between 2 (somewhat important) and 3 (very important). When examining relationships among the peer factor variables and math course taking, the importance to friends to attend classes regularly ($r = .28$), to get good grades ($r = .21$), and to continue education past high school ($r = .27$) are positively correlated with taking higher level math classes in high school. Of the peer factor variables, the item showing the strongest correlation with declaration of a STEM major after high school is the importance to friends to attend classes regularly ($r = .18$).

Math self-efficacy. The items representing mathematics self-efficacy (S1-S5) show strong positive relationships with correlations ranging from .77 to .87. Item means range from 2.38 to 2.68 representing rating scores between sometimes and often. When examining the relationships between the self-efficacy items and mathematics course taking and STEM major, these items show stronger correlations with the outcome variables than the social resource items. Correlations between the self-efficacy items and highest mathematics course taken range from .33 to .38, with "can do an excellent job on math assignments" ($r = .38$) showing the strongest relationship. The efficacy items showing the strongest correlation with STEM major were "can do an excellent job on math assignments" ($r = .34$) and "can master math class skills" ($r = .34$). Students that rate their ability to understand and do well in math highly are more likely to take more advanced math courses and high school and declare a STEM major two years after leaving high school.

Outcome Variables

The outcome variable of highest mathematics course, taken from students' high school transcripts, has an overall mean of 5.56 representing the average highest math course taken by students by the end of high school between middle academic math II (algebra II) and advanced math I (trigonometry, analytical geometry, statistics). The highest math course taken correlates positively ($r = .50$) with declaration of a STEM major two years after leaving high school supporting prior research finding math course taking serves as a pathway to STEM in college. Also consistent with trends in STEM majors, the mean for STEM is 0.09; therefore, out of the ELS sample of 13,980 students who were 10th grade students in 2002, in 2006 only 9% had declared majors in science, technology, engineering, or mathematics.

Group Comparisons for Model Variables

Prior to structural equation modeling and hierarchical linear modeling, t-tests were run to determine differences in the model variables based on socioeconomic status, gender, and ethnicity. Variable means and standard deviations by group are displayed in Table 5. The t-test analyses are show in Table 6.

Table 5.

Means and Standard Deviations of Model Variables by Group (SES, Gender, and Ethnicity)

	SES above average (N=6930)		**SES** below average (N=6980)		**Gender** male (N=6710)		**Gender** female (N=7190)		**Ethnicity** White/Asian (N=9290)		**Ethnicity** Black/Hispanic (N=3830)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ACH	42.99	11.04	34.34	11.10	39.48	12.23	37.88	11.49	41.58	11.19	31.82	10.68
T1	2.98	0.63	2.91	0.67	2.93	0.69	2.96	0.61	2.96	0.63	2.92	0.68
T2	2.93	0.68	2.85	0.71	2.87	0.72	2.91	0.67	2.92	0.68	2.84	0.73
T3	2.78	0.75	2.76	0.76	2.74	0.77	2.79	0.73	2.76	0.74	2.80	0.78
T4	2.66	0.79	2.73	0.82	2.65	0.83	2.73	0.77	2.65	0.79	2.80	0.83
T5	2.86	0.55	2.75	0.62	2.81	0.60	2.80	0.58	2.85	0.55	2.71	0.66
P1	2.21	0.66	2.01	0.69	2.04	0.68	2.18	0.68	2.14	0.68	2.05	0.69
P2	2.32	0.68	2.08	0.73	2.12	0.71	2.27	0.70	2.23	0.71	2.14	0.72
P3	2.20	0.65	2.02	0.67	2.04	0.66	2.18	0.66	2.13	0.67	2.08	0.66
P4	2.49	0.59	2.37	0.64	2.37	0.63	2.48	0.60	2.45	0.61	2.40	0.65
P5	1.88	0.72	1.65	0.71	1.72	0.71	1.81	0.74	1.76	0.72	1.81	0.75
P6	2.44	0.62	2.27	0.70	2.27	0.69	2.43	0.64	2.34	0.66	2.41	0.68
F1	2.54	0.57	2.44	0.60	2.42	0.60	2.56	0.55	2.51	0.58	2.47	0.59
F2	2.28	0.62	2.22	0.63	2.15	0.63	2.34	0.61	2.25	0.62	2.29	0.63
F3	2.48	0.58	2.43	0.61	2.38	0.61	2.52	0.58	2.45	0.59	2.49	0.61
F4	2.61	0.57	2.46	0.63	2.45	0.62	2.61	0.58	2.55	0.60	2.54	0.62
S1	2.66	0.94	2.47	0.90	2.72	0.91	2.45	0.92	2.60	0.93	2.52	0.92
S2	2.47	0.96	2.28	0.90	2.57	0.93	2.22	0.92	2.40	0.94	2.33	0.92
S3	2.56	0.99	2.40	0.94	2.64	0.96	2.36	0.96	2.50	0.97	2.47	0.96
S4	2.75	0.94	2.54	0.94	2.76	0.93	2.56	0.95	2.67	0.94	2.60	0.95
S5	2.79	0.93	2.56	0.93	2.80	0.92	2.59	0.95	2.70	0.94	2.66	0.94
COURS	6.09	1.50	5.00	1.56	5.48	1.67	5.61	1.57	5.78	1.61	5.01	1.50
STEM	0.11	0.32	0.05	0.22	0.11	0.31	0.06	0.24	0.09	0.29	0.06	0.24
NOCHOICE	0.16	0.33	0.13	0.33	0.14	0.34	0.15	0.35	0.16	0.36	0.10	0.31

Table 6.

T-Tests for Model Variables by SES, Gender, and Ethnicity

Variable	**SES** above average/below average (N=13960)		**Gender** male/female (N=13960)		**Ethnicity** White or Asian/Black or Hispanic (N=13960)	
	$\overline{X}_{above} - \overline{X}_{below}$	*t*	$\overline{X}_{male} - \overline{X}_{fem}$	*t*	$\overline{X}_{WorA} - \overline{X}_{AAorHis}$	*t*
ACH	8.65	46.08***	1.60	7.94***	9.76	46.91***
T1	0.07	5.90***	-0.03	-2.70**	0.04	2.71**
T2	0.09	6.97***	-0.03	-2.69**	0.07	5.12***
T3	0.02	1.38	-0.04	-3.19**	-0.04	-2.61**
T4	-0.07	-4.54***	-0.08	-5.74***	-0.15	-9.07***
T5	0.11	10.78***	0.02	1.64	0.14	11.30***
P1	0.21	16.17***	-0.14	-10.44***	0.09	5.66***
P2	0.24	18.20***	-0.15	-11.18***	0.09	5.53***
P3	0.18	14.04***	-0.13	-10.65***	0.05	3.30**
P4	0.13	10.75***	-0.11	-9.71***	0.04	2.82**
P5	0.22	16.37***	-0.08	-5.97***	-0.05	-2.88**
P6	0.17	13.43***	-0.16	-12.38***	-0.07	-4.29***
F1	0.10	8.29***	-0.14	-11.52***	0.04	2.54*
F2	0.07	5.15***	-0.19	-14.49***	-0.04	-2.88**
F3	0.06	4.67***	-0.14	-11.48***	-0.05	-3.19**
F4	0.16	12.65***	-0.16	-12.53***	0.01	0.71
S1	0.19	10.28***	0.27	14.95***	0.08	3.58***
S2	0.19	10.43***	0.35	18.99***	0.07	3.26**
S3	0.16	8.30***	0.29	14.74***	0.03	1.16
S4	0.22	11.31***	0.20	10.14***	0.08	3.33**
S5	0.23	12.17***	0.21	10.85***	0.04	1.65
COURS	1.09	40.32***	-0.13	-4.44***	0.77	24.19***
STEM	0.06	13.31***	0.05	10.82***	0.04	6.69***
NOCHOICE	0.03	4.91***	-0.01	-1.38	0.05	6.93***

Note: * p<0.05, **p<0.01, ***p<0.001.

T-tests were conducted to compare students from above average SES and below average SES on prior achievement, coping resource indicator variables, outcome variables, and school policy on course selection and grouping. Based on the analyses, students with above average SES had significantly higher mean scores for all variables except for “teachers praise effort” and “teachers expect success in school”. Students with above average SES posted 10th grade achievement scores over 8 points higher, on average, than their below average SES counterparts. Furthermore, below average SES students left high school with less mathematics preparation, with a mean difference in course taking over one full pipeline category lower than above average

SES students. Additionally, above average SES students were more likely to declare STEM majors and attend schools without open enrollment for courses.

Comparing males and females, males scored significantly higher than females on the 10^{th} grade achievement test; however, the mean difference was not as dramatic as the one seen between SES groups with males scoring, on average, 1.6 points higher than females. For all of the indicator variables of the social coping resources (teacher, parent, and friend factors) females reported significantly higher average ratings than males except for the item “students get along well with teachers”. The opposite pattern in t values was seen for the self-efficacy indicators. For all items measuring mathematics self-efficacy, average female ratings of their abilities were significantly lower than average male ratings; although, based on student transcripts, females completed significantly higher levels of mathematics courses prior to high school completion. And, consistent with national trends, females were significantly less likely to have declared a STEM major two years after high school than males.

Examining the t-test analyses comparing racial groups traditionally represented in STEM fields (White and Asian) with racial groups traditionally underrepresented (African American and Hispanic) there is no clear pattern of mean differences between groups. White and Asian students recorded significantly higher average scores on the 10^{th} grade achievement test, higher average course taking, and more likelihood of declaring a STEM major as compared to underrepresented groups; however, mean differences for the indicator variables were inconsistent. For each of the social resource factors, underrepresented students reported ratings higher than White and Asian students on two indicator variables (T3 and T4; P5 and P6, F2 and F3). White and Asian students reported average ratings higher than African American and Hispanic students on the remaining items (except for F4, $p>.05$) in each of the factors. For three of the five self-efficacy items (S1, S2, and S4) White and Asian students reported higher average ratings; however, the means for the other two items (S3 and S5) were not significantly different between groups. When considering school policy on grouping and course selection, African American and Hispanic students were more likely to attend schools with open enrollment policies.

Differences based on SES and gender show clear patterns for the indicator variables. However, differences based on ethnicity are less consistent. Based on these preliminary analyses it is difficult to understand the interactions of SES, gender, and race as they are connected to the indicator, outcome, and school policy variables; therefore, a General Linear Model (GLM) was used to analyze the interactions of SES, gender, and race on the outcome variables and school policy variable. Additionally, to better understand how SES and gender function within each racial group on coping resources and course taking, separate hierarchical linear model analyses were conducted as a follow-up to the overall HLM model.

Examining Interactions Using GLM

To continue the preliminary analyses comparing means, a General Linear Model was employed to examine the main and interaction effects of the background variables on the outcome and policy variables. The general linear model goes a step beyond the multivariate regression model by allowing for linear transformations or linear combinations of multiple dependent variables. Repeated t-tests often increase Type I errors because separate univariate tests of significance for correlated dependent variables are not independent. Additionally, the general linear model is applied to analyze Multivariate Analysis of Variance (MANOVA) designs with categorical predictor variables. The results of the GLM tests are displayed in Table 7.

Table 7.

Effects of SES, Gender, and Ethnicity on Outcome and Policy Variables

Source	Variable	Type III SS	df	MS	F
Corrected Model	Math Course Taking	3524.577(a)	7	503.511	220.775***
	STEM major	18.171(b)	7	2.596	32.897***
	policy for different abilities	6.522(c)	7	.932	7.920***
Intercept	Math Course Taking	217392.372	1	217392.372	95320.330***
	STEM major	53.430	1	53.430	677.115***
	policy for different abilities	118.836	1	118.836	1010.088***
SES	Math Course Taking	1591.096	1	1591.096	697.650***
	STEM major	6.025	1	6.025	76.352***
	policy for different abilities	.281	1	.281	2.386
FEMALE	Math Course Taking	55.211	1	55.211	24.209***
	STEM major	3.566	1	3.566	45.195***
	policy for different abilities	.251	1	.251	2.134
RAC	Math Course Taking	491.589	1	491.589	215.548***
	STEM major	.734	1	.734	9.307**
	policy for different abilities	2.882	1	2.882	24.497***
SES * FEM	Math Course Taking	6.379	1	6.379	2.797
	STEM major	.351	1	.351	4.449*
	policy for different abilities	.060	1	.060	.512
SES * RAC	Math Course Taking	21.608	1	21.608	9.474**
	STEM major	.001	1	.001	.008
	policy for different abilities	.259	1	.259	2.200
FEM * RAC	Math Course Taking	5.911	1	5.911	2.592
	STEM major	.362	1	.362	4.582*
	policy for different abilities	.397	1	.397	3.371
SES * FEM * RAC	Math Course Taking	.594	1	.594	.260
	STEM major	.013	1	.013	.164
	policy for different abilities	.746	1	.746	6.339*
Error	Math Course Taking	23212.462	10178	2.281	
	STEM major	803.131	10178	.079	
	policy for different abilities	1197.429	10178	.118	
Corrected Total	Math Course Taking	26737.039	10185		
	STEM major	821.302	10185		
	policy for different abilities	1203.951	10185		

Note: * p<0.05, **p<0.01, ***p<0.001.

a R Squared (adjusted) = .131

b R Squared (adjusted) = .022

c R Squared (adjusted) = .005

Supporting the t-test findings, all main effects of SES, gender, and race on the outcome and policy variables were significant except for the effect of gender on school policy (F=2.386, p>0.05). Significant interaction effects were found between SES and gender for STEM major (F=4.45, p<0.05, see figure 3), SES and race for math course taking (F=9.47, p<0.01, see figure 4), gender and race for STEM major (F=4.58, p<0.05, see figure 5), and the three-way interaction of SES, gender, and race for school policy (F=6.34, p<0.05, see figure 6).

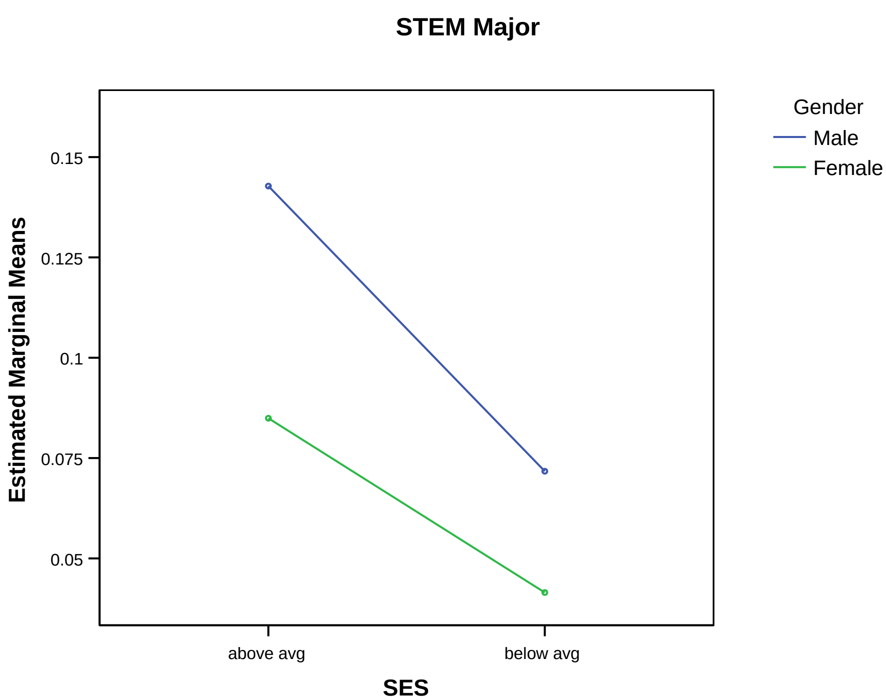

Figure 3. Estimated marginal means of STEM major as a function of SES and Gender.

Examining the significant interaction of SES and gender on STEM major, above average SES and being male was positively connected to STEM major; however, males with above average SES ($\overline{X} = .143$) benefited more from higher socioeconomic status than above average SES females ($\overline{X} = .085$). Females with above average SES did not show significantly higher mean scores for STEM major than males with below average SES ($\overline{X} = .072$). Consistent with previous STEM research, males from families with above average socioeconomic status were the most likely to pursue a STEM major.

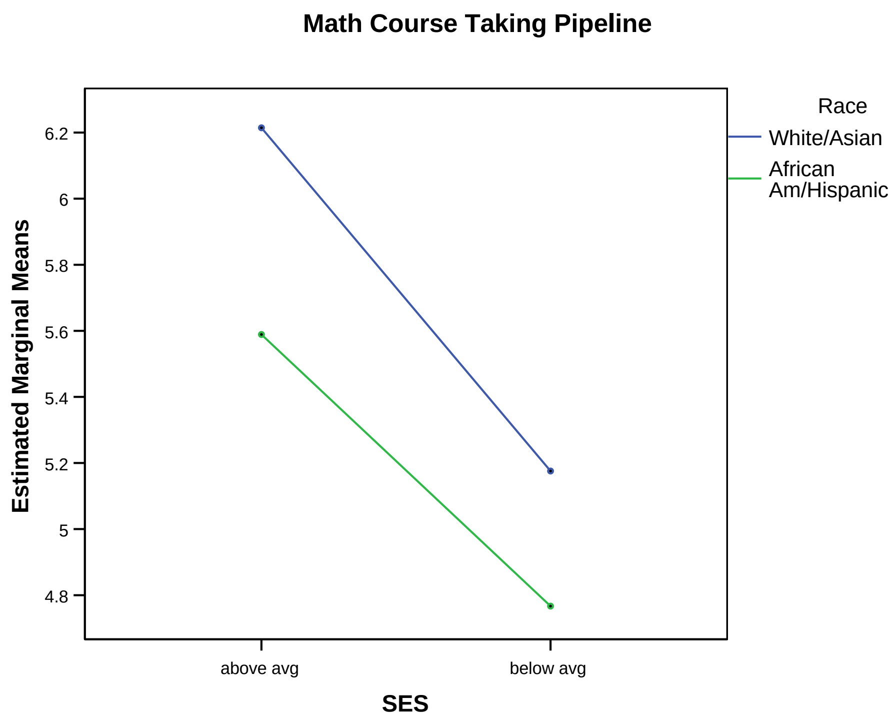

Figure 4. Estimated marginal means of math course taking as a function of SES and Race.

Consistent with previous findings on math course taking, overall, students from above average socioeconomic groups take higher level mathematics courses in high school. However this relationship shows a significant interaction with race. White and Asian students show increased benefit from higher socioeconomic status ($\overline{X} = 6.214$) than African American and Hispanic students ($\overline{X} = 5.589$) when compared to students from below average socioeconomic groups ($\overline{X}_{WandA} = 5.176, \overline{X}_{AAandHisp} = 4.767$).

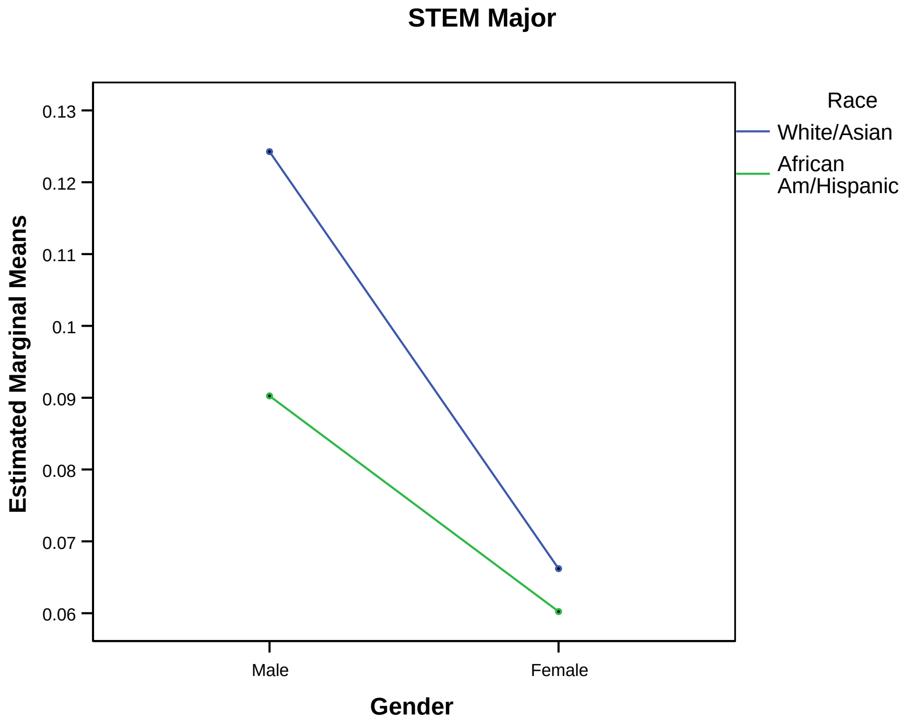

Figure 5. Estimated marginal means of STEM major as a function of Gender and Race.

Males ($\overline{X} = .107$), regardless of race, are more likely to declare a STEM major than females ($\overline{X} = .063$). However, there is a significant interaction between gender and race on the likelihood of declaring a STEM major. Examining this interaction, White and Asian males are more likely ($\overline{X} = .124$) to declare a STEM major than African American and Hispanic males ($\overline{X} = .090$). However, this trend is not the same for females. White and Asian females show a similar likelihood of declaring a STEM major ($\overline{X} = .066$) with African American and Hispanic females ($\overline{X} = .060$).

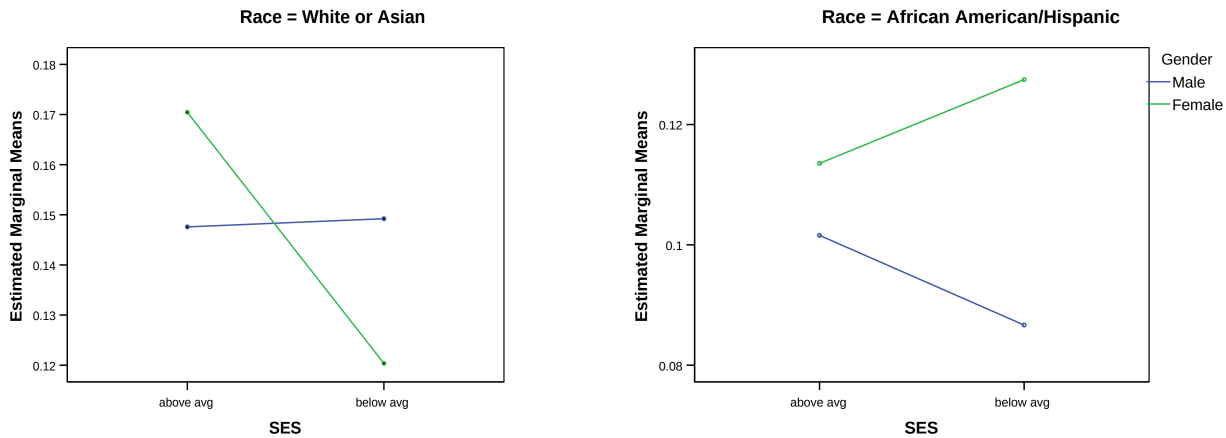

Figure 6. Estimated marginal means of school policy as a function of Gender and SES at each Race, White/Asian and African American/Hispanic.

Examining the significant three-way interaction of SES, gender, and race on school policy for addressing students with different abilities, interesting trends in school policies, that differ from those reported in previous research, emerge. For White and Asian males, students from above average SES backgrounds are just as likely to attend schools with limited enrollment and differentiated curricula ($\bar{X} = .148$) as males from below average SES ($\bar{X} = .149$). White and Asian females of above average SES are slightly more likely to attend schools with limited enrollment policies ($\bar{X} = .170$) than females of below average SES ($\bar{X} = .120$). However, when I examine the mean scores of African American and Hispanic students different trends in school policy are evidenced. Females from above average socioeconomic backgrounds ($\bar{X} = .114$) and below average SES backgrounds ($\bar{X} = .127$) show a similar likelihood to attend schools with limited enrollment and differentiation policies as their White and Asian counterparts. African American and Hispanic males, on the other hand, are less likely to attend schools with limited enrollment, with males from above average SES ($\bar{X} = .102$) more likely to have limited choice and grouping than those from below average SES ($\overline{X} = .087$). Males from underrepresented racial groups are most likely to attend high schools with open enrollment policies.

These findings suggest the investigation of grouping policies, and their impact on course taking, take advantage of the nested structure of the data. Examining the difference in course taking between races nested within schools using HLM analyses is warranted.

Structural Equation Modeling

Structural equation models, including the measurement and structural models, were estimated using Mplus statistical software (Muthen & Muthen, 1998-2004). Maximum likelihood estimation was used to test the models. Relationships among and between factors and observed variables for dependent variable factors (e.g. social and personal resources) were examined and are described using linear regression equations. Relationships for binary (STEM major) or ordered categorical observed (math pipeline) are described by a set of probit or logistic regression equations. Mplus provides robust estimation of standard errors and robust chi-square tests of model fit taking into account non-normality of outcomes (Muthen & Muthen, 1998-2004).

Measurement model

First, the measurement model was tested to ensure the data had acceptable fit with the model composed of the scales explored with the factor analyses and proposed by previous research. Measuring the relationships between the latent variables and their indicator variables, the latent variables of student/teacher relationship, student/parent academic discussions, peer academic importance, and mathematics self-efficacy were included in the model. The results for measurement model were assessed using indices of model fit including chi-square, comparative fit index (CFI), Tucker Lewis Index (TLI), and root mean square error of approximation (RMSEA).

The measurement model included the twenty indicator variables hypothesized to load on the four correlated latent variables. The fit statistics are shown in Table 8. The initial chi-square value is statistically significant. The other fit indices show acceptable fit of the model. CFI (.983) and TLI (.991) are above the recommended .95. RMSEA (.055) is slightly higher than the criterion value of .05. Although the measurement model shows good fit, four modifications were made to the model allowing the error variances of T1: “The teaching is good”, and T2: “Teachers are interested in students” to correlate resulting in better model fit (CFI=.983, TLI=.992, and RMSEA=.053). The second modification allowed the error variances of P1: “How often discussed school courses with parents” and P2: “How often discussed school activities with parents” to correlate further improving the fit indices (CFI=.985, TLI=.992, and RMSEA=.051). Next, the error variances of S1: “Can do an excellent job on math tests” and S2: “Can understand difficult math texts” were freed to correlate (CFI=.987, TLI=.994, and RMSEA=.047). Based on recommended modification indices, a final modification was made allowing the error variance of S3: “Can understand a difficult math class” to correlate with the error variance of S2. When making data driven decisions for model modification, the change must support theory. All modifications to the measurement model correlate errors between items from the same scale measuring the same construct. It makes sense substantively that student responses to similar items would have correlated errors. After make the final modifications to the model, fit indices are within the recommended limits (CFI=.989, TLI=.994, and RMSEA=.044), and the model shows acceptable fit with the data.

Table 8.

Summary of Fit Statistics for Measurement Model

Model	χ^2	df	χ^2 / df	CFI	TLI	RMSEA
1 Initial	2304.522	54	42.676	.983	.991	.055
2 T1 WITH T2	2243.739	55	40.795	.983	.992	.053
3 P1 WITH P2	2028.407	55	36.880	.985	.993	.051
4 S1 WITH S2	1734.536	54	32.121	.987	.994	.047
5 S2 WITH S3						
Final	1507.498	54	27.917	.989	.994	.044

Note. *N* = 13980.

Standardized factor loadings for the indicator variables are presented in Table 9. To standardize the latent factors the variance of all factors was set to 1. The reliabilities of the indicators (square of factor loading) and variance extracted estimates are also provided.

Table 9.

Indicator Loadings and Variance Explained for Measurement Model

Construct	Denoted	Indicator Variable	Standardized Loading	R^2	Variance Extracted
Teacher Factor					.47
	T1	The teaching is good.	.69	.47	
	T2	Teachers are interested in students.	.75	.56	
	T3	Teachers praise effort.	.66	.44	
	T4	Teachers expect success in school.	.59	.35	
	T5	Students get along well with teachers.	.62	.38	
Parent Factor		How often discussed			.55
	P1	school courses with parents.	.74	.55	
	P2	school activities with parents.	.75	.56	
	P3	things studied in class with parents.	.81	.66	
	P4	grades with parents.	.78	.61	
	P5	prep for ACT/SAT with parents.	.70	.49	
	P6	going to college with parents.	.81	.65	
Peer Factor		Important to friends			.80
	F1	to attend classes regularly.	.89	.80	
	F2	to study.	.79	.63	
	F3	to get good grades.	.87	.75	
	F4	to continue education past high school.	.84	.71	
Math Self-Efficacy					.76
	S1	Can do an excellent job on math tests.	.87	.76	
	S2	Can understand difficult math texts.	.82	.68	
	S3	Can understand difficult math class.	.90	.81	
	S4	Can do excellent job on math assignments.	.94	.88	
	S5	Can master math class skills.	.93	.87	

Note. *N* = 13980.

According to Fornell and Larcker's (1981) criteria, a variance extracted of greater than 0.50 indicates the validity of the construct is high. For the Teacher Factor construct the variance extracted estimate was slightly lower than .50. However, this estimate test is conservative and given the significant factor loadings and high reliabilities, the construct is retained in the measurement model. The full measurement model including error terms is displayed in Figure 7.

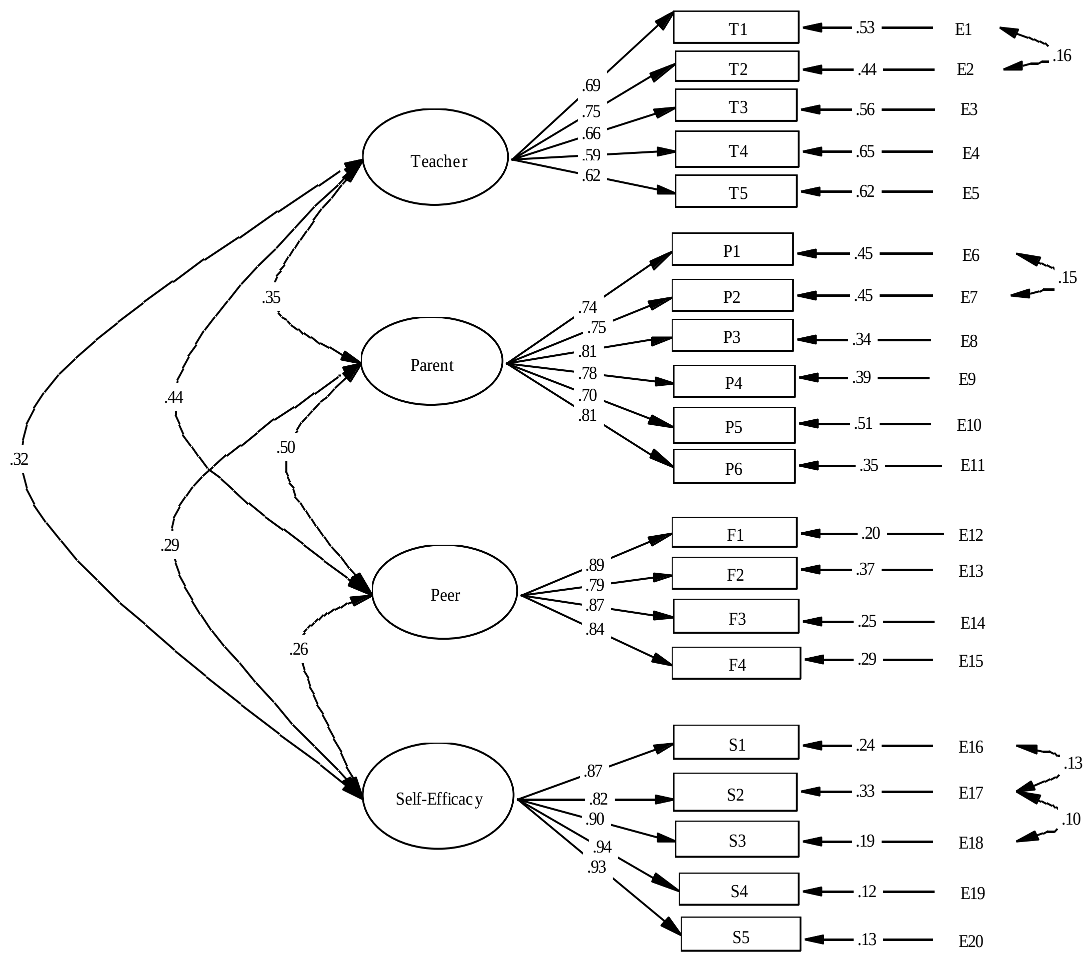

Figure 7. Latent structure of indicators for the measurement model.

The standardized loadings for the teacher factors range from .59 to .75. For the scale representing frequency of academic discussions between the student and parent, loadings are high and range from .70 to .81; and, for the importance of academic behaviors for peers, loadings range from .79 to .89. Finally, for the math self-efficacy scale factor loadings are high (from .82

to .94); these high factor loadings suggest the items are good indicators of the four constructs and the model should be retained as the measurement model.

Structural Models

After development of the full measurement model, structural models were specified and estimated to test the study's hypotheses. Finally, the full structural model tests the hypothesized relationships between background, latent, and outcome variables as shown in Figure 2.

Hypothesis 1. Locations in social structures (female, African American/Hispanic, and low SES) are related to student personal resources to cope with stressors or threats measured by mathematics self-efficacy. These relationships are direct as well as indirect, mediated by prior math achievement.

a. *SES (below average) is related to lower levels of math achievement and lower levels of math self-efficacy.*
b. *Gender (female) is related to math self-efficacy demonstrated by higher levels of mathematics achievement, but lower levels of math self-efficacy.*
c. *Race (African American/Hispanic) is related to math self-efficacy demonstrated by lower levels of math achievement and lower levels of math self-efficacy.*

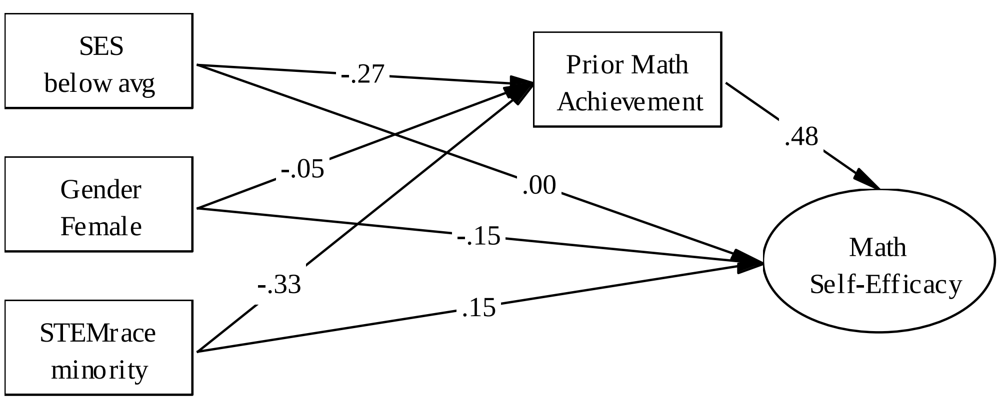

Figure 8. Structural model of underrepresented groups on math self-efficacy (hypothesis 1).

The indices for this model indicate good fit with the data (CFI=.997, TLI=.998, and RMSEA=.049) supporting the hypothesis that social background are related to achievement and self efficacy. The model variables explained approximately 23% of the variance in prior mathematics achievement and 23% of the variance in mathematics self-efficacy. Examining the relationships between SES, prior math achievement, self-efficacy (hypothesis 1a), as predicted there is a significant, negative direct effect of below average SES on math achievement (β= -.27) with students from lower socioeconomic backgrounds scoring lower on the 10^{th} grade math achievement test. Contrary to the hypothesized relationship, the direct effect of low SES on math self-efficacy was not significant (β= .00); however, the indirect effect of low SES on math self-efficacy through prior math achievement (β= -.13) was significant and in the negative direction.

Being female has as significant, negative direct relationship with math self-efficacy (β= -.15) supporting hypothesis 1b. Based on previous findings, I expected the relationship from female to math prior achievement to be positive as female math achievement has been shown to be reaching parity in recent years, and in some cases females are outscoring their male counterparts in achievement measures; however, the path from female to achievement was in the negative direction (β= -.05) although the effect was small. The indirect effect of gender on self-efficacy through prior math achievement was -.03. It is possible the use of math IRT as the achievement measure, providing a score considering item difficulty, may produce slightly different results than other studies using a raw or scaled score for achievement. And, although the effect of gender on achievement was not in the predicted direction, the effect was small.

Consistent with prior research, and supporting hypothesis 1c, being African American or Hispanic had a significant, negative relationship with math prior achievement (β= -.33). However, contrary to hypothesis 1c, the direct relationship between minority race and math self-efficacy was positive (β= .15). The indirect relationship of race on self-efficacy through prior achievement was negative (β= -.13). One possible explanation for a positive self-efficacy relationship although, as a group, the relationship to achievement is negative is the disidentification of racial minority students with test scores. Borrowing from Steele's research, it is possible earning a lower score on a test of math achievement is not as likely to translate into negative math self-concept for African American and Hispanic students as it is for other racial groups. Exploring other models with more variables may help to better understand this finding.

Hypothesis 2. Locations in social structures are related to measures of social resources.

a. *SES (below average) is related to social resources as demonstrated in lower levels of teacher, parent, and peer factors.*
b. *Gender (female) is related to social resources as demonstrated in higher levels of teacher, parent, and peer factors.*
c. *Race (African American/Hispanic) is related to social resources as demonstrated in lower levels of teacher, parent, and peer factors.*

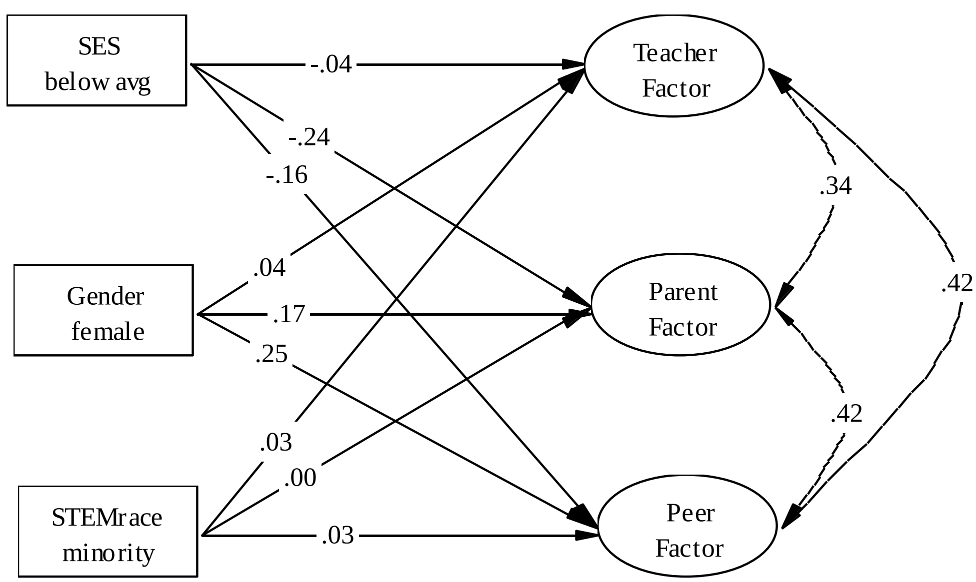

Figure 9. Structural model of underrepresented groups on social resources (hypothesis 2).

The model testing the relationships between background variables and social support variables (see figure 9) shows acceptable fit with the data (CFI=.964, TLI=.978, and RMSEA=.048). Examining the correlations among the social support factors, the latent social variables are strongly correlated with coefficients ranging from .34 to .42. Therefore, students who report higher student/teacher relationship ratings are more likely to have more frequent discussions with their parents about academics, and they are more likely to have friends who believe positive academic behaviors are important. It is important to note that although the model shows acceptable fit, the variance explained for the three factors is low with less than 1% of the variance in teacher factor, 8% of variance in the parent factor, and 8% of variance in peer factor explained by the model.

Supporting hypothesis 2a, below average SES has a significant negative effect on the social resource variables with students from below average socioeconomic backgrounds reporting significantly lower student/teacher relationship ratings (β= -.04), fewer academic discussions with parents (β= -.24), and lower academic behavior importance for friends (β= -.16).

Model results of the relationships between gender and the social resource variables support hypothesis 2b: girls are more likely to report positive student/teacher relationship ratings (β= .04), have more frequent academic discussions with their parents (β= .17), and report positive academic behaviors are more important to their friends (β= .25).

The effects of underrepresented race on teacher, parent, and peer factors were not in the expected direction. Being African American or Hispanic showed a small, but significant, positive relationship with student/teacher relationship ratings (β= .03). The relationship between race and frequency of parent discussions about academics was not significant (β= .00); and, there was a significant effect of minority race on positive academic behaviors being important to friends (β= .03).

Hypothesis 3. Social resources are related to personal resources. Social resources facilitate math self-efficacy.

a. *Measures of teacher as a social resource are related to higher math self-efficacy.*
b. *Parents' academic focus is positively related to math self-efficacy.*
c. *A higher peer academic focus is related to higher math self-efficacy.*

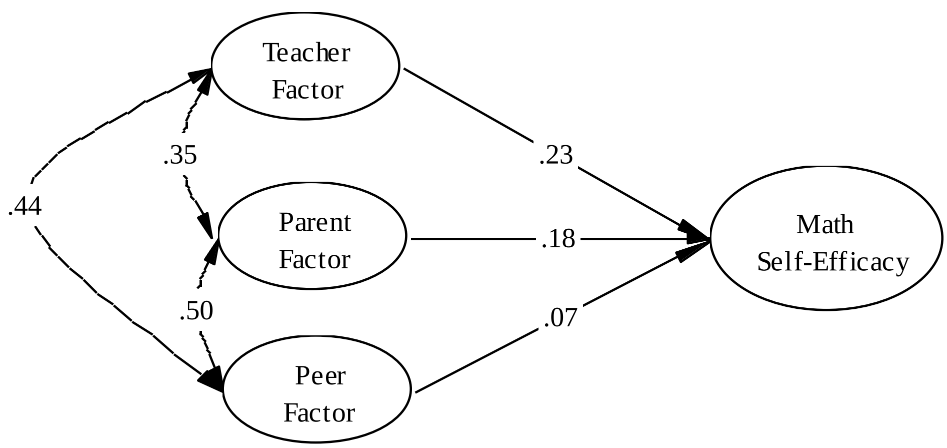

Figure 10. Structural model of social resources on mathematics self-efficacy (hypothesis 3).

With fit indices acceptable (CFI=.989, TLI=.994, and RMSEA=.044), the model specified to test the relationships between the social resource factors and the personal resource of math self-efficacy explains approximately 14% of the variance in math self-efficacy. As predicted in the hypotheses statements, the social resources of student/teacher relationship (β= .23), frequency of student/parent academic discussions (β= .18), and importance of academic behaviors to friends (β= .07) show positive effects on math self-efficacy. Consistent with the previous model, the three social resource factors are highly correlated. Therefore, students who rate high on teacher factor, parent factor, and peer factor also report higher math efficacy-related beliefs.

Hypothesis 4. Higher level math course taking in high school (math pipeline) is positively related to declaration of a STEM major in college.

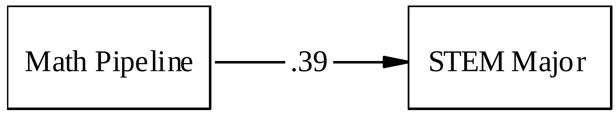

Figure 11. Relationship of mathematics course taking on STEM major (hypothesis 4).

Indicating a direct relationship between math course taking and STEM major, hypothesis 4 is supported with course taking explaining over 27% of the variance in STEM major. Although course taking is a strong predictor of STEM major (β= .39), it does not show a strong enough relationship to be considered as proxy for STEM major as intended. However, based on the results of the t-test and GLM analyses it is important to consider the role of SES, gender, and race on course taking as well as STEM major. With course taking a significant predictor of STEM major and school policy on course selection and grouping showing significant interaction effects, understanding how the background variables and social and personal resources function nested within school policy may help to elucidate discrepancies in the mathematics preparation needed to make a STEM major a possible choice for students.

Hypothesis 5. Measures of social and personal resources are related to identification with STEM disciplines as evidenced by higher level math courses and enrollment in a STEM major.

a. *A higher teacher factor is positively related to the math pipeline measure directly as well as STEM indirectly, mediated by math pipeline.*

b. *Frequency of parent/student academic discussions is positively related to the math pipeline directly as well as STEM indirectly, mediated by math pipeline.*

c. *A higher peer academic behavior importance is related to a higher level in the math pipeline directly as well as STEM indirectly, mediated by math pipeline.*

d. *Mathematics self-efficacy is positively related to the math pipeline and declaration of a STEM major.*

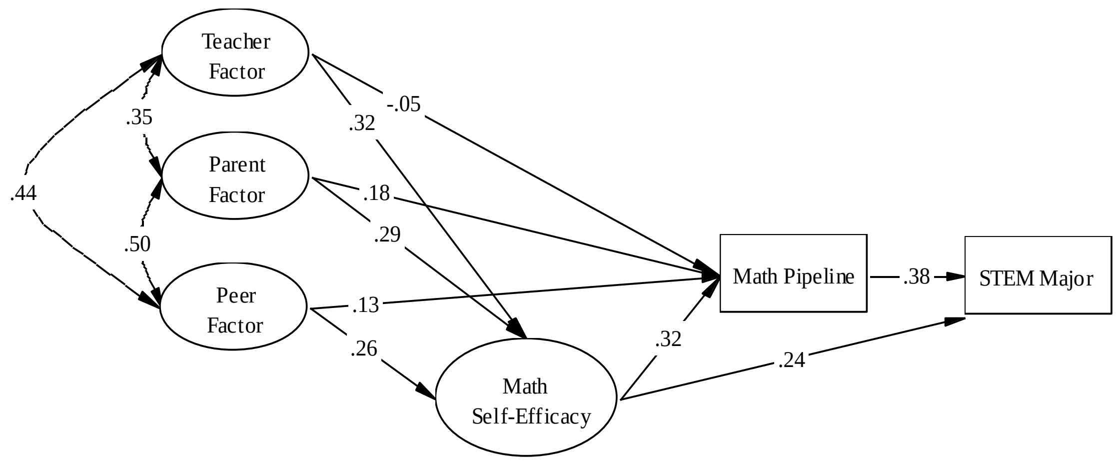

Figure 12. Structural model of social and personal resources on course taking and STEM major (hypothesis 5).

The structural model specified to test the relationships between coping resources, math course taking, and STEM matriculation explains 21% of the variance in course taking and 27% of the variance in STEM major. It fits the data well with a CFI of .988, TLI of .994, and RMSEA of .043. Similar to the structural models discussed previously, the social support variables correlate highly (ranging from .35 to .50), the social support variables have a positive effect on math self efficacy with coefficients ranging from .26 to .32, and math course taking is a significant predictor of STEM matriculation (β= .38).

Examining the effects of the student/teacher relationship factor on math pipeline directly, the relationship is in the opposite direction than predicted in hypothesis 5a. A more positive student/teacher relationship rating is directly related to lower levels of course taking (β= -.05) and indirectly to a lower likelihood of declaring a STEM major (β= -.02). Although this finding contradicts research findings that show a positive relationship between teacher/student relationship and achievement, it is possible teachers spend more time with students who are struggling academically; therefore, struggling students may have a higher opinion of the teaching but it does not translate into higher course taking and subsequent STEM matriculation.

As predicted, the frequency of student/parent academic discussions is a significant, positive predictor of the math pipeline measure directly (β= .18) as well as indirectly predicting STEM matriculation through course taking (β=.07). Students who have more frequent discussions with their parent(s) about academics during high school take higher level math courses and are more likely to select a STEM major after high school.

The importance of academic behaviors for friends is also a significant positive predictor of higher level course taking directly (β= .13) and STEM matriculation indirectly (β= .05), supporting the assertion of hypothesis 5c. Students who report it is important to their friends to attend class, study, get good grades, and continue their education take higher level math classes and are more likely to pursue a STEM degree.

In the model, math self-efficacy has the strongest relationship with math course taking and pursuit of a STEM degree with efficacy beliefs predicting the math pipeline measure (β= .32) and STEM matriculation (β= .24) directly. Furthermore, self-efficacy indirectly impacts STEM major through course taking (β= .13). Students with higher math efficacy are more take more challenging math courses and are more likely to declare a STEM major in college.

Hypothesis 6. Structural locations are related, independently of coping resources, to STEM identification.

a. *SES (below average) is negatively related to STEM identification as evidenced by lower pipeline level and reduced likelihood of STEM major.*
b. *Gender (female) is negatively related to STEM identification as demonstrated in a lower level in the math pipeline and reduced likelihood of choosing a STEM major.*

c. Race (African American/Hispanic) is related to outcomes as demonstrated in lower math pipeline and STEM majors.

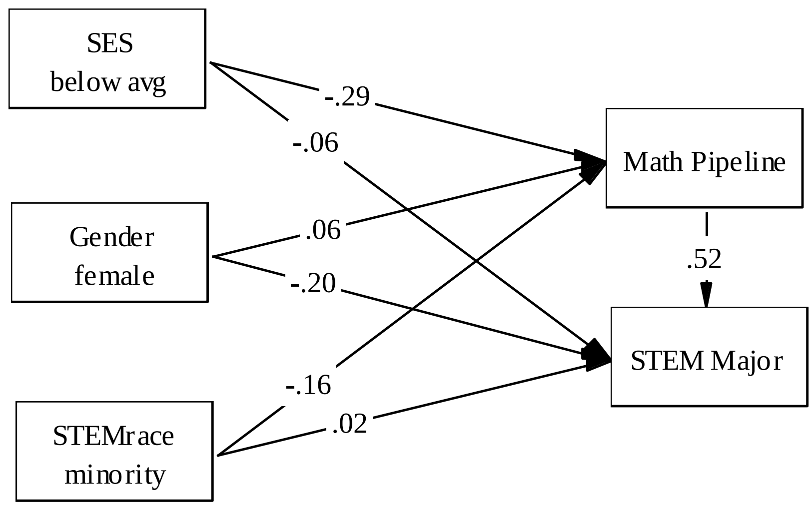

Figure 13. Model of underrepresented groups on math course taking and STEM major (hypothesis 6).

In the structural model of background variables on math course taking and STEM matriculation, the relationships explain 14% of the variance in course taking and 31% of the variance in STEM major. As hypothesized, below average SES has a negative impact on the math pipeline measure (β= -.29) and STEM major directly (β= -.06) as well as indirectly through math course taking (β= -.15). Examining the assertions of hypothesis 6b, females are less likely to pursue a STEM degree (β= -.20); however, contrary to the hypothesis, being female is positively related to higher level math course taking (β= .06) and STEM major indirectly through course taking (β= .03). Minority race has a small, but positive effect on STEM major (β= .02) directly. However, when considering the course taking of African American and Hispanic students, race has a significant, negative impact (β= -.16) and race, mediated by course taking, has a significant, negative indirect effect on STEM major (β= -.08). The total effect of race on STEM major is -.18. The results of this model uphold previous trends in course taking and

STEM matriculation: students with below average SES, females, and African American and Hispanic students less likely to pursue a STEM degree. Additionally, students from lower socioeconomic groups, as well as African Americans and Hispanics, take lower level math courses in high school. Females do not follow the same pattern, as females take higher level math courses in high school although this course taking does not necessarily lead to the declaration of a STEM major in college.

Full Structural Model. After testing the six hypotheses separately to better understand the relationships of background variables, prior achievement, social resources, math self-efficacy, math course taking and STEM major, all variables were considered in a full structural model. Although the proposed model showed acceptable fit (CFI=.980, TLI=.988, and RMSEA=.049), the model was modified post hoc based on modification indices and results from the previous hypothesis testing. All observed and latent variables were retained in the final model, with paths added (1) from prior achievement to teacher and parent factors; and, (2) from gender to STEM major. The first modification, adding paths from prior achievement to teacher and parent factors, improved model fit evidenced by the fit indices and a reduced chi-square, degrees of freedom ratio. The second modification, adding a direct path from gender to STEM major resulted in an increase in the variance of STEM major explained by the model. Table 10 contains goodness-of-fit statistics for the model initially as well as after modification. Figure 14 visually displays the magnitude and direction of model coefficients.

Table 10.

Summary of Fit Statistics for Full Structural Model

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA
1 Initial	2741.500	80	34.269	.980	.988	.049
2 ACH→Teacher ACH→Parent	2229.746	82	27.192	.984	.991	.043
3 Gender→STEM	2217.070	82	27.037	.984	.991	.043

Note. *N* = 13980.

The final model explains 52% of the variance in mathematics course taking and 32% of the variance in declaration of STEM major, and it shows a good fit with the data (CFI=.984, TLI=.991, and RMSEA=.043). The variance explained for the latent constructs of social and personal resources are: 2.4% for student/teacher relationship; 12% for student/parent frequency of academic discussions; 9% for peer academic importance; and, 34% for mathematics self-efficacy. Standardized direct, indirect, and total effects are displayed in Table 11.

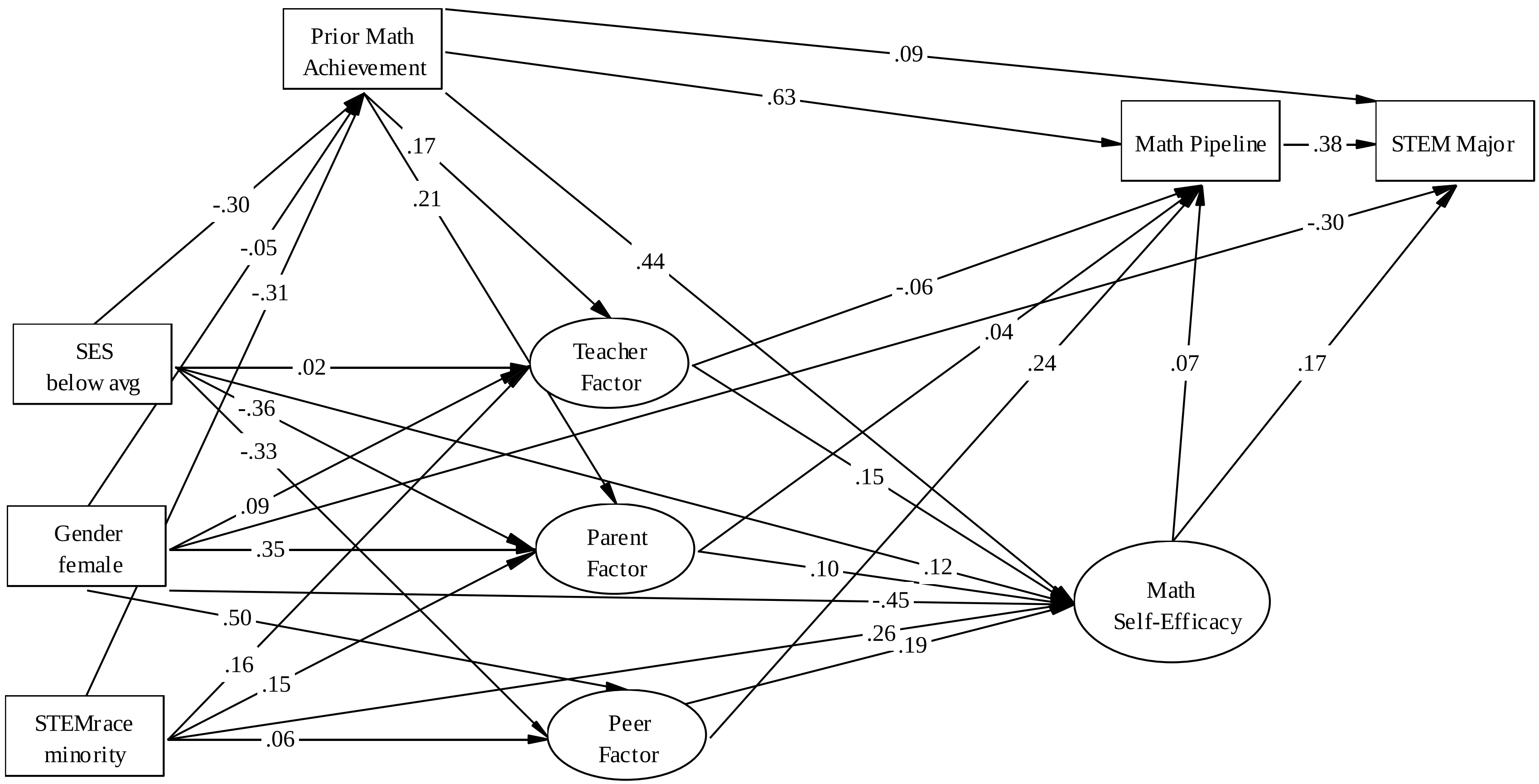

Figure 14. Final structural equation model.

Table 11.

Standardized Direct, Indirect, and Total Effects for Final Structural Model

	Prior Achievement 10th grade math IRT			*Social Resources* Teacher Factor			Parent Factor			Peer Factor			*Personal Resource* Math Self-Efficacy		
	direct	*indirect*	*total*	*direct*	*indirect*	*total*	*direct*	*indirect*	*total*	*direct*	*indirect*	*total*	*direct*	*indirect*	*total*
Social Structure															
SES	-.30		-.30	.02	-.10	-.08	-.36	-.12	-.48	-.33		-.33	.12	-.39	-.27
Gender	-.05		-.05	.09	-.01	.08	.35	-.02	.33	.50		.50	-.45	.10	-.35
STEM Race	-.31		-.31	.16	-.11	.05	.15	-.14	.01	.06		.06	.26	-.28	-.02
Prior Achievement															
10th grade IRT				.17		.17	.21		.21				.44	.05	.49
Social Resources															
Teacher Factor													.15		.15
Parent Factor													.10		.10
Peer Factor													.19		.19

Note. *N* = 13980. All path coefficients were significant at p<.05.

Table 11 (continued).

Standardized Direct, Indirect, and Total Effect for Final Structural Model

	Math Course Taking Math Pipeline			*STEM Identification* STEM major		
	direct	*indirect*	*total*	*direct*	*indirect*	*total*
Social Structure						
SES		-.78	-.78		-.30	-.30
Gender		.10	.10	-.30	-.04	-.34
STEM Race		-.64	-.64		-.23	-.23
Prior Achievement						
10th grade IRT	.63	.03	.66	.09	.33	.42
Social Resources						
Teacher Factor	-.06	.01	-.05		.01	.01
Parent Factor	.04	.01	.05		.04	.04
Peer Factor	.24	.02	.26		.13	.13
Personal Resources						
Math Self-Efficacy	.07		.07	.17	.02	.19
Math Course Taking						
Math Pipeline				.38		.38

Note. *N* = 13980. All path coefficients were significant at p<.05.

STEM major. Likelihood of declaring a STEM major two years out of high school was directly impacted by gender, prior achievement, self-efficacy, and the level of math course taking. The strongest direct effect on STEM major was the math pipeline measure (β=.38) with students who took higher level math courses more likely to declare a STEM major in college. Gender also had a strong direct effect, but in the opposite direction (β=-.30); the indirect effect of being female on STEM major was relatively weak (β=-.04). Females are less likely to matriculate into a STEM major than males, but in this model this relationship is affected most my being female, not through the other model variables. Prior mathematics achievement had a relatively weak direct effect on STEM major (β=.09); however, the indirect effect of achievement through the social and personal resources as well as course taking was strong (β=.33) with a total effect of (β=.42) 10th grade mathematics achievement is a significant predictor of STEM matriculation in college. Student math self-efficacy had a moderate direct effect (β=.17) on STEM major and a weak indirect effect through course taking (β=.02). Considering the direct effects of the model variables on STEM major, male students with high math achievement, strong efficacy beliefs, and high-level course taking are more likely to pursue a degree in a STEM discipline.

Examining the indirect effects, the background variables of SES, minority race, and social resources contributed to STEM matriculation indirectly through other model variables. For the model variables only specified as indirectly affecting STEM major, below average SES had a strong negative effect (β=-.30) with students from more disadvantaged backgrounds less likely to pursue a STEM major but the effects are through other model variables such as prior achievement, social resources, self-efficacy, and course taking. Being African American or Hispanic also had a strong negative effect on STEM matriculation (β=-.23) through other model variables. Examining the social resources, peer academic importance had the strongest indirect effect (β=.13) on STEM major. Teacher/student relationship (β=.01) and frequency of parent/student academic discussions (β=.04) had significant, but small, effects. Therefore, SES, race, and peer academic importance affect the decision to major in a STEM field, but only indirectly through other model variables.

Math pipeline. Direct effects of model variables on math course taking were specified for prior achievement, social resources, and math self-efficacy. Prior math achievement is the strongest predictor of high-level math course taking directly (β=.63). Prior achievement also has an indirect effect on course taking through social resources and self-efficacy, but the effect is small (β=.03). Student ratings of the student/teacher relationship had a small negative effect on course taking directly (β=-.06) but a small positive effect indirectly through self-efficacy (β=.01).

The frequency of parent/student academic discussions also had a small effect directly (β=.04) as well as indirectly (β=.01) but in the positive direction. Of the social resources, peer academic importance had the greatest effect on math course taking both directly (β=.24) and indirectly (β=.02). Math self-efficacy also had a direct positive impact on the math pipeline measure (β=.07). Considering the results of variables with direct effects on math course taking, student with high 10th grade math achievement, friends who believe academic behaviors are important, high self-efficacy, and more frequent parent discussions about academics are more likely to take challenging math courses in high school.

The background variables of social structure had significant indirect effects on high school math course taking. Below average SES had a strong negative impact (β=-.78) as did minority race (β=-.64). Being female had a smaller, but significant, positive relationship on course taking (β=.10). Therefore, although the direct impact of background variables was not specified, students from more socioeconomically disadvantaged backgrounds, as well as African American and Hispanic students, did not take as many high level math courses in high school. Females took higher level math classes than males. These effects were measured through the effects of other model variables including prior achievement, social factors, and self-efficacy.

Math self-efficacy. Social resource factors, prior achievement, and social structure variables directly impacted self-efficacy beliefs. The social resources of student/teacher relationship (β=.15), student/parent academic discussions (β=.10), and peer academic importance (β=.19) had significant positive impacts on efficacy related beliefs although the effects were moderate. Prior math achievement had the strongest total effect (β=.49) on self-efficacy impacting efficacy beliefs directly (β=.44) and indirectly (β=.05). The strongest effect of the background variables was gender with a strong, negative direct effect (β=-.45) and a small, positive indirect effect (β=.10) on self-efficacy. Both minority race and below average SES had positive direct effects on self-efficacy (β=.26 and β=.12 respectively); however, the overall effect of these background variables was negative (β=-.02 for race and β=-.27 for SES) because the indirect effects of these variables were strong in the negative direction. These results suggest students with strong prior achievement scores, better relationships with teachers, more frequent conversations with parents about school, and friends who value academics are have higher math self-efficacy. Being female is directly linked to lower math self-efficacy, while students from below average socioeconomic backgrounds and those from underrepresented racial groups are linked to positive self-efficacy directly, but lower self-efficacy overall when considering the other model variables.

Social resource factors. Examining the direct effects of social structure variables and prior achievement on the student/teacher relationship, all variables have a direct, positive impact on student ratings of teachers in high school. The largest effect is prior achievement (β=.17) on teacher factor. Student background variables show different patterns of effect. Underrepresented race is a direct, positive predictor of student/teacher relationship (β=.16); however, when considering the indirect impact of race through prior achievement (β=-.11), the total effect is smaller but still positive (β=.05). Gender has a positive direct effect on teacher factor (β=.09), a small indirect effect through prior achievement (β=-.01) for a small, positive total effect (β=.08). SES, on the other hand, has a small, positive direct effect (β=.02) and a moderate, negative indirect effect (β=-.10); therefore, the overall of effect of below average SES on ratings of the student/ teacher relationship is negative (β=-.08).

Prior math achievement also has a significant, positive direct effect on frequency of student/parent discussions about academics (β=.21). Below average SES has the strongest effect on the parent factor with a direct effect of β=-.36 and an indirect effect of β=-.12. Gender and race show similar patterns: being female has a positive direct effect on frequency of academic discussions (β=.35) and a small negative indirect effect (β=-.02); being African American or Hispanic has a moderate, positive direct effect on parent factor (β=.15) with a negative indirect effect (β=-.14). Therefore, females from above average socioeconomic backgrounds with high prior achievement report more frequent discussions with their parents about school and academics.

Peer academic importance was specified as having direct effects from the student background variables of SES, gender and race. The largest direct effect on the peer factor was gender (β=.50) with females more likely to report academics are important to their friends. Students from below average SES reported academics were less important for their friends (β=-.33) While African American and Hispanic students reported academics were more important to their friends (β=.06) although the effect was small.

10th grade math IRT. Underrepresented group membership had a negative impact on 10th grade mathematics achievement. The largest direct effects was for African American and Hispanic students (β=-.31) who scored lower on the 10th grade achievement test. Also, having below average SES had a significant negative impact on prior achievement (β=-30). Females also had lower prior achievement (β=-.05) although the effect was small.

Hierarchical Linear Modeling

First, an overall model was examined using the data of all racial groups. Using the fully unconditional model the intraclass correlation was calculated and 20% of the variance in higher level mathematics course taking is between schools supporting the use of a multilevel model. And, the average student has a higher level course taking of 5.437 (as represented by the coefficient in the unconditional model) meaning the highest level mathematics course students studied, on average, was between (5) middle academic math II (algebra II) and (6) advanced math I (trigonometry, analytical geometry, statistics). The fully unconditional model is shown by the equations below.

Level 1 (student level)

$$Math_{ij} = \beta_{0j} + r_{ij}\,.$$

where

$Math_{ij}$ represents the math course-taking of each student *i* in school *j*.

β_{0j} represents the school mean math course-taking of school *j*.

r_{ij} represents the random error of student *i* in school *j*.

i = 1, 2, 3, . . ., n*j* students in school *j*.

j = 1,2, ...J schools.

Level 2 (school level)

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

where

γ_{00} represents the grand mean math course-taking for all schools.

u_{0j} represents the random school effect, the deviation of school *j*'s mean from the grand mean.

The fully unconditional model established a baseline value for the fit index (deviance score). Next, the conditional model was analyzed to determine model fit for the overall data. The predictors at level-1 are: the social structure background variables of SES, gender, and race; prior math achievement; and, the coping resources of parent factor, peer factor, teacher factor, and self-efficacy. In the second level of the analysis, how these effects vary across schools with different policies on course enrollment and differentiation is considered. The policy factor used in level-2 is *NOCHOICE*, which are schools without open enrollment policies. The analyses will allow me to compare the effects of the level-1 variables nested in schools with open enrollment, and those without open enrollment on high school mathematics course taking. Descriptive statistics for level-1 and level-2 variables are displayed in Table 12.

Table 12.

Descriptive Statistics for HLM Overall Model Variables

		N	Percentage (categorical)	Mean	SD
Student Level					
Math Course taking		12790		5.45	1.66
Social Structure					
SES		13950		0.05	0.75
Gender (female)		13950		0.50	0.50
STEM Race (minority)		13180		0.28	0.45
Prior Achievement					
10^{th} grade math IRT		13710		38.32	11.83
Coping Resources					
Parent Factor		11080		2.15	0.51
Peer Factor		9520		2.42	0.51
Teacher Factor		12720		2.81	0.49
Math Self-Efficacy		10180		2.52	0.85
School Level					
Closed Enrollment (no student choice)	Yes	120	18%		
	No	530	82%		
	Total	650			

Note: Sample size is unweighted and rounded to the nearest ten.

The conditional model was built using model specification procedures suggested by Raudenbush and Bryk (2002): (1) at level 1, specify one variable at a time adding each predictor after all others are removed to avoid collinearity; (2) specify all level 2 predictors and check significance levels, remove insignificant effects from the slopes and then the intercepts, use deviance difference test to evaluate the model changes. The steps for building the conditional model as well as equations for level-1 and level-2 analyses are displayed in Table 13.

Table 13.

Taxonomy of HLM Model for Overall Data

Model	Level-1	Level-2
1 Intercept-Only	$Math_{ij} = \beta_{0j} + r_{ij}$	$\beta_{0j} = \gamma_{00} + u_{0j}$
2 Add demographics Random components: SES RACE	$Math_{ij} = \beta_{0j} + \beta_{1j}SES + \beta_{2j}SEX + \beta_{3j}STEMrace + r_{ij}$	$\beta_{0j} = \gamma_{00} + u_{0j}$ $\beta_{1j} = \gamma_{10} + u_{1j}$ $\beta_{2j} = \gamma_{20}$ $\beta_{3j} = \gamma_{30} + u_{3j}$
3 Add prior achievement Random component: MathAch	$Math_{ij} = \beta_{0j} + \beta_{1j}SES + \beta_{2j}SEX + \beta_{3j}STEMrace + \beta_{4j}MathAch + + r_{ij}$	$\beta_{0j} = \gamma_{00} + u_{0j}$ $\beta_{1j} = \gamma_{10} + u_{1j}$ $\beta_{2j} = \gamma_{20}$ $\beta_{3j} = \gamma_{30} + u_{3j}$ $\beta_{4j} = \gamma_{40} + u_{4j}$
4 Add coping resources Random components: Friends SelfEfficacy	$Math_{ij} = \beta_{0j} + \beta_{1j}SES + \beta_{2j}SEX + \beta_{3j}STEMrace + \beta_{4j}MathAch +$ $\beta_{5j}Parent + \beta_{6j}Friends + \beta_{7j}Teacher + \beta_{8j}SelfEfficacy + r_{ij}$	$\beta_{0j} = \gamma_{00} + u_{0j}$ $\beta_{1j} = \gamma_{10} + u_{1j}$ $\beta_{2j} = \gamma_{20}$ $\beta_{3j} = \gamma_{30} + u_{3j}$ $\beta_{4j} = \gamma_{40} + u_{4j}$ $\beta_{5j} = \gamma_{50}$ $\beta_{6j} = \gamma_{60} + u_{6j}$ $\beta_{7j} = \gamma_{70}$ $\beta_{8j} = \gamma_{80} + u_{8j}$

Table 13 (continued).

Taxonomy of HLM Model for Overall Data

Model	Level-1	Level-2
5 Add school-level enrollment policy to intercept and SES	$Math_{ij} = \beta_{0j} + \beta_{1j}SES + \beta_{2j}SEX + \beta_{3j}STEMrace + \beta_{4j}MathAch +$ $\beta_{5j}Parent + \beta_{6j}Friends + \beta_{7j}Teacher + \beta_{8j}SelfEfficacy + r_{ij}$	$\beta_{0j} = \gamma_{00} + \gamma_{01}(NOCHOICE) + u_{0j}$
		$\beta_{1j} = \gamma_{10} + \gamma_{11}(NOCHOICE) + u_{1j}$
		$\beta_{2j} = \gamma_{20}$
		$\beta_{3j} = \gamma_{30} + u_{3j}$
		$\beta_{4j} = \gamma_{40} + u_{4j}$
		$\beta_{5j} = \gamma_{50}$
		$\beta_{6j} = \gamma_{60} + u_{6j}$
		$\beta_{7j} = \gamma_{70}$
		$\beta_{8j} = \gamma_{80} + u_{8j}$

Model 1 is the fully unconditional model used to establish a baseline of model fit for the conditional model. The deviance statistic was 54931.71 with 2 parameters estimated by the model. As mentioned above, the average level of high school math course taking was 5.43. Examining the variance components, the estimate at level-1, 2.19 is the variance in course taking between students within schools, and 0.54 ($p<.01$) is the variance in course taking between schools. These random effects suggest a difference in course taking for individuals within schools as well as differences across schools. With 20% of the variance in course taking at the school level, the use of a 2-level model was warranted.

After establishing a baseline model, the fixed regression coefficients were analyzed. To assess the contribution of each individual level explanatory variable, a model was analyzed with all of the level 1 explanatory variables fixed and the corresponding variance components of the slopes fixed to zero. Using Full Maximum Likelihood (FML) estimation, the improvement of the final model was assessed by computing the difference of the deviance of this model and the fully unconditional model. To examine whether school policy on course enrollment explains between-school variation in mathematics course taking, FML estimation was used to formally test the improvement of fit.

The slopes of the explanatory variables were tested to assess if there was a significant variance component between the groups. Initially all variance components were included in the model and the chi-square test based on deviance was used to test model fit. Data-driven decisions were made to eliminate random components on a variable-by-variable basis. If the removal of a slope resulted in a significant decrease in model fit, the slope was included in the model although the variance component was insignificant. The fixed and random effects for models 1 through 5 are displayed in Table 14.

Table 14.
Fixed and Random Effects of Overall HLM Model

		Model 1 *Intercept-only*	Model 2 *Demographics*	Model 3 *Prior Achievement*	Model 4 *Coping Resources*	Model 5 *Enrollment Policy*
Fixed Effects						
Intercept	γ_{00}	5.43** (0.03)	5.47** (0.03)	5.28** (0.03)	3.78** (0.09)	3.77** (0.10)
Closed Enrollment	γ_{01}					0.14* (0.06)
SES	γ_{10}		0.66** (0.02)	0.27** (0.02)	0.22** (0.02)	0.25** (0.02)
Closed Enrollment	γ_{11}					-0.10* (0.05)
Female	γ_{20}		0.21** (0.02)	0.30** (0.02)	0.26** (0.03)	0.27** (0.03)
Minority STEM race	γ_{30}		-0.50** (0.04)	0.01 (0.03)	0.02 (0.04)	0.03 (0.04)
Prior Achievement	γ_{40}			0.08** (0.00)	0.08** (0.00)	0.08** (0.00)
Parent Factor	γ_{50}				0.23** (0.03)	0.25** (0.03)
Peer Factor	γ_{60}				0.15** (0.03)	0.12** (0.03)
Teacher Factor	γ_{70}				0.08** (0.03)	0.09** (0.03)
Self-Efficacy	γ_{80}				0.19** (0.02)	0.19** (0.02)

		Model 1			Model 2			Model 3			Model 4			Model 5		
Random Effects		τ	*df*	χ^2	τ	*df*	χ^2	τ	*df*	χ^2	τ	*df*	χ^2	τ	*df*	χ^2
Intercept	μ_{0j}	.54**	742	4340.9	.33**	580	1615.7	.24**	574	1510.5	.65**	455	553.3	.57*	393	452.1
SES	μ_{1j}				.09**	580	844.3	.03**	574	692.0	.02	455	478.9	.03	393	420.2
Minority STEM race	μ_{3j}				.21**	580	751.8	.12**	574	687.2	.11**	455	529.2	.12**	394	470.9
Prior Achievement	μ_{4j}							.00**	574	820.3	.00**	455	562.4	.00**	394	503.8
Peer Factor	μ_{6j}										.04*	455	519.7	.02	394	415.0
Self-Efficacy	μ_{8j}										.01**	455	567.5	.01**	394	489.0
Level-1 effect	r_{ij}	2.19			1.91			1.26			1.11			1.12		

Table 14 (continued).

Fixed and Random Effects of Overall HLM Model

	Model 1 *Intercept-only*	Model 2 *Demographics*	Model 3 *Prior Achievement*	Model 4 *Coping Resources*	Model 5 *Enrollment Policy*
Model Fit					
Deviance	54931.71	49914.23	43644.83	28438.91	24854.45
# of parameters	2	7	11	22	22
Δ deviance		5017.48	6269.40	15205.92	3584.46
Δ *df*		5	4	11	0

Note. Prior achievement τ values for random effects are significant although they show .00 values. This effect is due to the lack of measurement error using a single measure of mathematics achievement. *p<0.05, ** p<0.01.

Model 2 added the social structure background variables of SES, gender, and race with all of the random effects estimated. All fixed effects were significant and all random effects were significant except for the effect of female. This conditional model had a deviance of 49905.00 with 11 parameters estimated. The model was estimated again after omission of the gender random component. The new deviance was 49914.23 with 7 parameters estimated. The chi-square change from the proposed model 2 to the modified model was not significant so the modified model was accepted. All of the individual level variables have significant slopes. Students with higher SES (β=0.66, t=29.51, $p < 0.01$) who are female (β=0.21, t=8.56, $p < 0.01$) took higher level math classes, students who are African American or Hispanic (β= -0.50, t= -13.47, $p < 0.01$) took classes at a lower level in the math pipeline. The slopes of SES (τ=0.09, χ^2=844.25, $p<0.01$) and minority race (τ =0.21, χ^2=751.83, $p<0.01$) vary significantly between schools, but the slope of female does not vary significantly between schools.

Prior math achievement, centered on the grand mean, was added in model 3. With a deviance of 43644.83 and 11 parameters estimated, model 3 shows significantly better fit than the fully unconditional model and model 2. However, after adding prior achievement, the fixed effect of race is no longer significant (β=0.01, t=0.18, $p > 0.05$). Although race does not show a significant slope, the random effect is significant (τ=0.12, χ^2=692.02, $p<0.01$) with the slope of race varying significantly between schools; therefore, the main effect of race was retained in the model. Considering prior achievement, female students (β=0.30, t=14.38, $p < 0.01$) who are from higher socioeconomic backgrounds (β=0.27, t=14.96, $p < 0.01$) with higher scores on their 10^{th} grade math achievement test (β=0.08, t=63.82, $p < 0.01$) take courses higher in the math pipeline.

In model 4 the coping resources of parent factor, peer factor, teacher factor, and self-efficacy were added. With an initial deviance of 28424.15 and 37 parameters estimated, model 4 showed significantly better fit than model 3. However, many of the random components were not significant and were removed from the model one at a time. First, the random variance of the slope of teacher factor was fixed to zero. The deviance statistic did not increase significantly indicating that the removal of the factor from the model did not worsen model fit. Next, the random variance of parent factor slope was fixed to zero. Comparing deviance statistics, the removal of the parent factor random component did not significantly impact fit. The random component of SES was also insignificant; however if it is removed from the model the model shows significantly worse fit. When examining the results of the fixed effects, students from a higher socioeconomic background (β=0.22, t=11.43, $p < 0.01$), who are female (β=0.26, t=10.34, $p < 0.01$) with higher prior achievement (β=0.08, t=54.18, $p < 0.01$) and report higher parent (β=0.23, t=9.09, $p < 0.01$), peer (β=0.15, t=5.23, $p < 0.01$), and teacher (β=0.08, t=3.18, $p < 0.01$) factor scores as well as evidence higher mathematics self-efficacy (β=0.19, t=11.81, $p < 0.01$) take more high level mathematics courses in high school. With significant random effects, the slopes of race (τ=0.11, χ^2=529.17, p<0.01), prior achievement (τ=0.00, χ^2=562.35, p<0.01), friend factor (τ=0.04, χ^2=519.65, p<0.01), and self-efficacy (τ=0.01, χ^2=567.49, p<0.01) vary significantly between schools.

The school policy variable of limiting student course enrollment was added with model 5. Initially hypothesized to interact with all variables except for parent factor, the school policy variable was added first to the intercept and then to each variable one at a time, comparing model fit with each modification. When added to the intercept, school policy on course enrollment produced a significant effect and a model with a deviance statistic of 24855.63 and 22 parameters estimated. Next, course enrollment policy was added to SES, and there was not a significant change in fit so the modification was retained. After each successive modification, the model showed significantly worse fit; therefore, the interaction with school policy was only estimated for the intercept and SES in the final, overall model.

When examining fixed effects for the overall model, there is a significant association between school enrollment policies and the level of math course taking. Students at schools without open enrollment take more high-level math courses than students at schools with open enrollment (β=0.14, t=2.36, $p < 0.05$). Additionally, in schools that limit student choice of courses, the association between SES and course taking is weaker than in schools with open enrollment policies (β= -0.10, t= -2.11, $p < 0.05$).

Examining slope, all individual level variables, except for underrepresented race, have significant slopes. Students with higher SES (β=0.25, t=10.44, $p < 0.01$), who are female (β=0.27, t=9.73, $p < 0.01$) with higher prior achievement (β=0.08, t=50.05, $p < 0.01$), as well as higher parent (β=0.25, t=9.06, $p < 0.01$), peer (β=0.12, t=4.15, $p < 0.01$), teacher (β=0.09, t=2.98, $p < 0.01$), and self-efficacy (β=0.19, t=11.06, $p < 0.01$) factor scores take more high-level math classes.

To assess if there was a significant variance component between schools, the random components were estimated. The slopes of minority race (τ=0.12, χ^2=470.89, $p<0.01$), prior achievement (τ=0.00, χ^2=503.77, $p<0.01$), and self-efficacy (τ=0.01, χ^2=489.00, $p<0.01$) vary significantly between schools. The random variances of the slopes for SES and peer factor were not significant showing the slopes of these variables do not vary between schools. However, if the random components of SES and peer factor are removed from the model the model shows significantly worse fit.

Comparing the final model to the fully unconditional model, adding school course selection policy to level 2 explained an additional 12% of the variance in course taking between schools. The deviance statistic of the intercept-only model was 54931.71 with 2 degrees of freedom. The deviance statistic of the final model was 24854.45 with degrees of freedom of 22. Therefore, the full model shows significantly better fit than the fully unconditional model.

After separating the data by race the final, overall model was tested to examine the fit for different racial groups. The descriptive statistics of the variables in the separate data sets are displayed in Table 15. Before model estimation, the *STEMrace* variable was removed. For interpretation purposes, the model of fixed effects was held constant for all four racial groups. This made it possible to compare coefficients between racial groups to determine if relationships between social and personal resource variables and course taking vary based on the race of the student. Testing of random slope variation was done for each of the four models by including all random effects and then examining the significance levels of the variance slope components. Insignificant variance slope components were fixed to zero if the result did not significantly impact model fit. This series of analyses resulted in four final models with the same fixed effects and different variance components for the slope (see Table 16).

Table 15.

Descriptive Statistics for HLM Model Variables by Race

	White			*Asian*			*African American*			*Hispanic*		
	N	$\overline{X}$	SD	N	$\overline{X}$	SD	N	$\overline{X}$	SD	N	$\overline{X}$	SD
Student Level												
Math Course taking	7540	5.61	1.62	1220	6.16	1.71	1500	4.94	1.52	1800	4.92	1.56
Social Structure												
SES	8170	0.21	0.70	1320	0.06	0.86	1700	-0.21	0.68	1980	-0.34	0.73
Gender (female)	8170	0.50	0.50	1320	0.47	0.50	1700	0.50	0.50	1980	0.50	0.50
Prior Achievement												
10^{th} grade math IRT	8080	40.92	11.05	1280	41.95	12.33	1670	30.40	9.80	1930	32.53	11.11
Coping Resources												
Parent Factor	6930	2.16	0.50	1000	2.14	0.53	1150	2.19	0.53	1400	2.08	0.51
Peer Factor	6000	2.41	0.51	860	2.50	0.47	930	2.47	0.52	1200	2.40	0.52
Teacher Factor	7570	2.81	0.49	1140	2.85	0.46	1540	2.79	0.52	1760	2.83	0.51
Math Self-Efficacy	6370	2.52	0.85	930	2.67	0.82	1030	2.49	0.82	1280	2.46	0.83
School Level												
Closed Enrollment (no student choice)	600	0.18	0.38	360	0.18	0.39	390	.17	0.38	450	0.15	0.36

Note: Sample size is unweighted and rounded to the nearest ten.

Table 16.

Fixed and Random Effects of HLM Model by Race

	Parameter		*White*			*Asian*			*African American*			*Hispanic*	
Fixed Effects													
Intercept	γ_{00}		3.76**			4.98**			3.29**			3.48**	
			(0.12)			(0.30)			(0.32)			(0.29)	
Closed Enrollment	γ_{01}		0.24**			-0.14			0.14			0.11	
			(0.07)			(0.14)			(0.12)			(0.13)	
SES	γ_{10}		0.36**			0.03			0.26**			0.12	
			(0.03)			(0.05)			(0.07)			(0.06)	
Closed Enrollment	γ_{11}		-0.22**			-0.01			0.16			0.10	
			(0.06)			(0.14)			(0.13)			(0.12)	
Female	γ_{20}		0.26**			0.26**			0.25**			0.33**	
			(0.03)			(0.09)			(0.09)			(0.08)	
Prior Achievement	γ_{40}		0.07**			0.08**			0.07**			0.07**	
			(0.00)			(0.00)			(0.01)			(0.00)	
Parent Factor	γ_{50}		0.25**			0.21**			0.22*			0.29**	
			(0.03)			(0.08)			(0.10)			(0.08)	
Peer Factor	γ_{60}		0.15**			0.00			0.07			0.03	
			(0.03)			(0.09)			(0.10)			(0.08)	
Teacher Factor	γ_{70}		0.08*			0.06			0.20*			0.10	
			(0.04)			(0.08)			(0.08)			(0.08)	
Self-Efficacy	γ_{80}		0.20**			0.21**			0.16**			0.15**	
			(0.02)			(0.05)			(0.06)			(0.05)	
Random Effects		τ	*df*	χ^2	τ	*df*	χ^2	τ	*df*	χ^2	τ	*df*	χ^2
Intercept	μ_{0j}	0.78**	425	533.05	0.12**	126	167.36	1.76*	87	120.53	.20**	337	505.17
Female	μ_{2j}	0.07**	426	522.43									
Prior Achievement	μ_{3j}	0.00**	426	621.53	0.00	127	130.26	0.00*	88	116.51			
Peer Factor	μ_{5j}							0.13*	88	119.60			
Teacher Factor	μ_{6j}	0.07**	426	524.30									
Level-1 effect	r_{ij}	1.02			1.08			1.20			1.22		
Model Fit		Deviance		*df*	Deviance		*df*	Deviance		*df*	Deviance		*df*
		16401.94		11	2439.86		4	2564.90		7	3353.72		2

Note. Prior achievement τ values for random effects are significant although they show .00 values. This effect is due to the lack of measurement error using a single measure of mathematics achievement. *p<0.05, ** p<0.01.

The fit of the overall model was examined using the data of White students. Because white students comprise the majority of students in the sample, the results by race are very similar to the results when considering all races collectively. The average white student had a higher level course taking of 5.61 meaning the highest level mathematics course students studied, on average, was between (5) middle academic math II (algebra II) and (6) advanced math I (trigonometry, analytical geometry, statistics).

When examining the fixed effects, school policy on course enrollment had a significant effect on higher level course taking for white students with students at school with limited choices taking courses higher in the math pipeline (β=0.24, t=3.37, $p < 0.01$). Furthermore, in schools without open enrollment, the association between SES and course taking is weaker for White students (β= -0.22, t= -3.98, $p < 0.01$). All individual level variables had significant slopes. Students with higher student SES (β=0.36, t=12.64, $p < 0.01$), females (β=0.26, t=7.53, $p < 0.01$), higher prior achievement (β=0.07, t=40.77, $p < 0.01$) as well as higher coping resources including: parent factor scores (β=0.25, t=7.52, $p<0.01$), friend factor scores (β=0.15, t=4.30, $p<0.01$), teacher factor scores (β=0.08, t=2.35, $p < 0.05$), and mathematics self-efficacy (β=0.20, t=9.72, $p < 0.01$) take more high level mathematics courses.

Although the fixed effects were similar to the overall model, estimating the model with White students produced different results for the random components. The slopes for female (τ=0.07, χ^2=522.43, $p<0.01$), prior achievement (τ=0.00, χ^2=621.53, $p<0.01$), and teacher factor (τ=0.07, χ^2=524.30, $p<0.05$) vary significantly between schools. Therefore, female students tend to take more high-level math courses but the degree to which gender effects course taking varies between schools. The same is true for students with higher prior achievement, as well as those who report strong teacher factor scores.

When using this model to examine Asian students' course taking behavior, results reveal the average Asian student has a higher level course taking of 6.16 meaning the highest level mathematics course students studied, on average, was between (6) advanced math I (trigonometry, analytical geometry, statistics) and (7) advanced math II (pre-calculus).

School policy on course enrollment does not have a significant effect on the level of course taking for Asian students. The individual level variables with significant slopes are female (β=0.26, t=3.01, p<0.01), prior achievement (β=0.08, t=18.605, p<0.01), parent factor (β=0.21, t=2.79, p<0.01), and self-efficacy (β=0.21, t=3.91, p<0.01). Only the slope for the intercept is significant (τ=0.12, χ^2=167.36, p<0.05) so the average course taking for Asian students varies between schools. The random effect of prior achievement was retained for model fit although the effect is not significant.

Analysis of the data of African American students shows the average African American student has a higher level course taking of 4.94 with the average student taking between (4) middle academic math I (algebra I and geometry) and (5) middle academic math II (algebra II) although the average is reaching level 5 with more students taking algebra II.

When examining the fixed effects, school policy on course choice does not have a significant effect on higher level course taking for African American students; however, all individual level variables except for friend factor have significant slopes. Students with higher SES (β=0.26, t=3.524, $p < 0.01$), females (β=0.25, t=2.74, $p < 0.01$), high prior achievement (β=0.07, t=12.99, $p < 0.01$), and higher coping resources of parent factor (β=0.22, t=2.34, p<0.05), teacher factor (β=0.20, t=2.52, $p < 0.05$), and self-efficacy (β=0.16, t=2.78, $p < 0.01$) take more high-level mathematics courses. The slopes of prior achievement (τ=0.00, χ^2=116.51, p<0.05) and friend factor (τ=0.13, χ^2=119.60, p<0.05) vary significantly between schools. Therefore, for

African American students, wealthier students and females with higher math scores who have higher self-efficacy, more frequent academic discussions with their parents, and positive relationships with their teachers tend to take more high-level math courses. The relationships of prior achievement and friend academic importance with course taking vary by school for African American students.

When using this model to examine Hispanic students' course taking behavior, the average Hispanic student has a course taking score of 4.92, so on average Hispanic students take between (4) middle academic math I (algebra I and geometry) and (5) middle academic math II (algebra II) although the average approaches level 5.

School policy on course choice does not have a significant effect on higher level course taking for Hispanic students. Examining fixed effects, females ($\beta=0.33$, $t=4.15$, $p < 0.01$), high prior achievement ($\beta=0.07$, $t=19.89$, $p < 0.01$), and higher coping resources of parent factor ($\beta=0.29$, $t=3.79$, $p<0.01$) and self-efficacy ($\beta=0.15$, $t=3.05$, $p < 0.01$) take more high-level mathematics courses. Only the slope for the intercept is significant ($\tau=0.20$, $\chi^2=505.17$, $p<0.01$) so the average course taking for Hispanic students varies between schools. For Hispanic students, females and students with higher math scores who have more frequent conversations with their parents about school and have higher self-efficacy take more high-level math courses. These relationships do not vary across schools.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

The purpose of this study was to test a proposed model of mathematics course taking and selection of a STEM field of study linking social structure background variables and coping resources with academic decision making. The initial model tested the relationships between advanced mathematics course taking and a college major in a STEM field. The second model linked background variables, coping resources, and mathematics course taking using the nested structure of the data to consider the role of school course enrollment policies on course taking for the overall population as well as separately by racial group. This chapter presents a summary and discussion of the findings as well as their implications for high school educators and parents. The study's limitations and suggestions for future research are presented.

Summary of Research Findings

The findings of this study are presented according to the variables used to develop the models, in order of social structure background variables, social resources, self-efficacy, and school policy on course enrollment.

Findings from General Linear Modeling

A General Linear Model (GLM) analyzed the interactions of SES, gender, and race on the outcome variables and school policy variable. Significant interaction effects were found between SES and gender for STEM major, gender and race for STEM major, SES and race for math course taking, and the three-way interaction of SES, gender, and race for school policy. The interaction of SES and gender on STEM major revealed males with above average SES benefited more from higher socioeconomic status than above average SES females. Females with above average SES did not show significantly higher mean scores for STEM major than males with below average

SES. Students from above average socioeconomic groups take higher level mathematics courses in high school; however this relationship shows a significant interaction with race. White and Asian students show an increased benefit of higher socioeconomic status than African American and Hispanic students. Males, regardless of race, are more likely to declare a STEM major with a significant interaction between gender and race. Examining this interaction, White and Asian males are more likely to declare a STEM major than African American and Hispanic males, but White and Asian females show a similar likelihood of declaring a STEM major with African American and Hispanic females. Consistent with previous STEM research, males from families with above average socioeconomic status were the most likely to pursue a STEM major.

The three-way interaction of SES, gender, and race on school policy indicates trends in school policies that differ from those reported in previous research (Oakes, 1990; Vanderhart, 2006). For White and Asian males, students from above average SES backgrounds are just as likely to attend schools with limited enrollment and differentiated curricula as males from below average SES. White and Asian females of above average SES are slightly more likely to attend schools with limited enrollment policies than females of below average SES. However, when examining the mean scores of African American and Hispanic students different trends in school policy are seen. Females from above average socioeconomic backgrounds and below average SES backgrounds show a similar likelihood to attend schools with limited enrollment and differentiation policies as their White and Asian counterparts. African American and Hispanic males are more likely to attend schools with open-enrollment policies with males from above average SES more likely to have limited choice and grouping than those from below average SES.

Findings from Structural Equation Modeling

Social Structure Background Variables

The structural models in this study considered the effects of the social structure variables of socioeconomic status, gender, and minority race on coping resources, math course taking, and declaration of STEM major. In this study I presented the social structural variables as stressors with the variables coded to examine the effects of background characteristics specific to underrepresentation in STEM disciplines, namely: low SES, female, and African American or Hispanic.

Low SES had strong effects on the variables in the model, especially when considering the indirect and total effects of low SES. Students from more disadvantaged backgrounds had significantly lower high school achievement test scores and this lower prior achievement had negative direct and indirect impacts on the student-teacher relationship, frequency of student-parent discussions about academics, math self-efficacy, course taking, and STEM identification. Additionally, students with below average SES reported academic behaviors such as attending class and getting good grades were not as important to their friends. SES was the strongest predictor of course taking level in high school. These findings support the work of many researchers who assert ineffective instructional arrangements widen the achievement gap by channeling poor students into lower achieving groups (Leonard, 2001; Schumm, Moody, & Vaughn, 2000; Saleh, Lazonder, & Jong, 2005; Vanderhart, 2006).

Below average socioeconomic status had consistent negative effects on model variables, being female, on the other hand, shows a different impact pattern in the model. Female had lower math prior achievement, however the effect was small. On the social resource variables of teacher, parent, and peer factors, being female had a strong positive impact. Girls reported stronger student-teacher relationships, more frequent student-parent academic discussions, and peers believing academic behaviors were important. Interestingly, although females were strongly tied to more social coping resources, the relationship with the personal coping resource of self-efficacy is in the opposite direction. Being female is a strong, negative predictor of math self-efficacy. The direct effect is tempered somewhat by a positive indirect path of female through the social resource variables; however, the total effect of being female on self-efficacy remains strong in the negative direction. Although females report significantly lower mathematics self-efficacy, they take higher level math classes in high school than males with female having a significant positive indirect effect on course taking through prior achievement and the coping resource variables. The advantages of mathematics preparation do not seem to benefit females in the same way as males as a pipeline for STEM matriculation. Females take more high-level math classes than males but are significantly less likely to declare a STEM major. In fact, the results of this study show, overall females are 34% less likely than males to matriculate in STEM by their second year in college.

The background variable of underrepresented STEM race is a strong, negative predictor of 10^{th} grade math achievement. Examining the relationships of race with the social resources of teacher, parent, and peer factors, an interesting pattern emerges especially for the teacher and parent factors which are indirectly impacted through prior achievement. Being African American or Hispanic has significant, positive direct relationships with quality of student-teacher relationship and frequency of student-parent academic discussions. However, the indirect effect of underrepresented race on these social variables through math prior achievement is negative. The overall effect of race on teacher factor and parent factor is small, and for parent factor insignificant, when considering the combined effect of the direct relationship and indirect relationship through prior achievement. Therefore the lower prior achievement of African American and Hispanic students has negative impacts on the social resources that could act as supports for minority students. The model only specifies a direct path from race to peer factor; the effect is positive but small. The relationship between underrepresented race and math self-efficacy shows a pattern similar to those for teacher and parent factors: directly being African American or Hispanic is a strong positive predictor of self-reported math efficacy beliefs; however indirect effects through prior achievement and social resources are strong and negative. When considering both direct and indirect effects, the overall effect of race on self-efficacy is small and in the negative direction. Underrepresented race is a strong negative predictor of both math course taking level and STEM matriculation indirectly through the model variables.

Prior Achievement

Supporting years of research showing the strong impact of prior achievement on student decision making and career path (Adelman, 1998), 10th grade math achievement was a strong direct predictor of student-teacher relationship, frequency of student-parent academic discussions, and math self-efficacy. For high school students, higher scores on the 10th grade math test are associated with more favorable academic relationships with teachers and parents and stronger beliefs about their abilities to learn and succeed in math. Prior achievement is a strong predictor of the level of math course taking a student will complete before graduation. The score on the 10th grade achievement test was also a significant predictor of STEM matriculation; however, the direct impact was small with the effects largely evidenced indirectly though coping resources and math course taking.

Coping Resources

The social resources of teacher, parent, and peer factors were moderate, but significant, direct predictors of math self-efficacy. Students with higher ratings of student-teacher relationships, frequency of student-parent discussions, and peer academic importance also reported higher levels of math efficacy. The largest impact of social resources on math course taking was from the peer factor. Students who reported academic behaviors were important to their friends were more likely to graduate having taken higher level math classes. The teacher and parent factors had much smaller effects on course taking with the student-teacher relationship having a small, negative impact on course taking and frequency of academic discussions with parents having a small, positive impact on course taking. Examining the indirect paths from social resources to STEM matriculation, peer factor had a moderate, positive relationship with STEM major through course taking. The indirect effects of teacher and parent factor on STEM major were small but positive. Therefore, of the social support variables, the relationship that shows the strongest effects on the outcome variables of the math pipeline and STEM matriculation is the perceived academic importance of peers.

Student beliefs about their ability to learn and succeed on math tasks were positive predictors of math course taking and STEM matriculation. Interestingly, the effects of efficacy beliefs on the math pipeline measure were small, while math self-efficacy was a moderate direct predictor of STEM matriculation. This difference in relationship magnitude is most likely affected by the gender difference in course taking and efficacy-related beliefs. Overall girls reported lower self-efficacy even though they took more high-level math classes than boys. This result likely weakened the connection between efficacy and course taking.

Math Pipeline

As suggested in previous research, high school math course taking is a strong predictor of STEM matriculation (Adelman, 1998). The effect of the math pipeline measure on declaration of STEM major in college was positive and strong. However, I was predicting a stronger relationship allowing for the use of math course taking as a proxy for STEM matriculation. The results did not evidence a relationship strong enough to consider math pipeline a proxy measure, although the importance of math course taking on the decision to pursue a STEM major is evidenced and further study of the relationships of study variables with course taking is warranted.

Findings from Hierarchical Linear Modeling

Overall Findings

Due to the nested structure of the data, HLM analyses were used to consider students within schools. First, the two-level model examining the impact of school policy on course selection was tested on the overall data. Approximately 20% of the total variance in mathematics course taking was explained at the school level indicating a large variation in student course taking between schools.

Student level analyses. The background characteristics of SES, gender, and race had significant effects on math course taking. In general, students from higher socioeconomic backgrounds and females studied higher-level mathematics courses in high school. African American and Hispanic students finished high school completing fewer high-level mathematics courses than their Asian and White counterparts; however, the effect of race on course taking became insignificant when mathematics prior achievement was added to the model. With 10^{th} grade math score a significant predictor of course taking, collinearity explains this change in effect because underrepresented race is strongly correlated with math prior achievement.

At the individual level all coping resource variables were significant. Students with more frequent student-parent discussions, higher teacher ratings, peers who valued academics, and higher self-efficacy competed more high-level math classes in high school. When considering these findings, it is important to note the resource variables are highly correlated, and therefore collinearity is an issue.

School level analyses. The school policy of student course selection was considered at the school level. This level of analyses compared the effects of schools with closed-enrollment policies and those with open-enrollment policies. A school closed-enrollment policy significantly impacted math course taking. Schools not allowing open-enrollment for core course selection had students taking more high-level math classes than schools with open-enrollment policies. This is a significant policy finding considering many schools use open-enrollment as a detracking policy; when, in fact, it is acting as a hidden stratification policy. Supporting the findings of Bradley and Charles (2004) as well as Van Langen, Bosker, and Dekkers (2006), in differentiated systems where there is more opportunity for student choice and academic placement, there is more opportunity for stereotyped choices. Possible reasons and implications for this finding are discussed further in the discussion section of the chapter.

School closed enrollment policy also interacted significantly with socioeconomic status. The negative relationship indicates that although students from higher SES backgrounds graduate with higher levels of course taking, in schools with limited course enrollment, SES has less of an effect on course taking than in schools with open enrollment policies. Therefore, it is possible schools that do not offer students course choice, course taking patterns show more similarities among students of different socioeconomic backgrounds.

The effects of race, prior achievement, and self-efficacy, as well as average course taking, varied across schools. Underrepresented race related to course taking differently in different schools with minority students taking more high-level math classes in some schools as compared to others. The effects of prior achievement as well as self-efficacy also varied across schools with these variables not showing the same pattern of relationship from school to school. The effects of

SES and social resource variables did not vary; therefore, SES, parent, peer, and friend factors show consistent patterns of effect on course taking regardless of school.

HLM Model by Race

School policies on differentiation of courses and course selection may affect students from minority groups differently than white students. Previous research has found ability grouping is most prevalent in schools with a large population of minority students, diverse levels of achievement, and impoverished students (Vanderhart, 2006). Therefore, school policy may have potentially harmful effects for minority or low-achieving students. Grouping practices often promote ineffective instructional arrangements which widen the achievement gap by channeling poor and minority students into lower achieving groups or tracks (Leonard, 2001; Schumm, Moody, & Vaughn, 2000; Saleh, Lazonder, & Jong, 2005; Vanderhart, 2006). To better understand if school policy on course selection increases course taking for students from different racial backgrounds similarly, or if closed enrollment policy benefits students from one group more than another, further analyses tested the model on groups separately.

Student level, differential effects. Examining the effects of individual predictors, gender, prior achievement, parent factor, and self-efficacy had similar patterns of effects for the four racial groups. Females, students with higher prior achievement, students reporting more frequent academic discussions with parents, and students with higher efficacy-related beliefs take higher level math courses within each racial group. SES and teacher factor are only significant predictors of course taking within the White data and African American data. In general, Asian and Hispanic student course taking was not significantly affected by family socioeconomic background or the quality of the student-teacher relationship. The perceived importance of academics to friends was only a significant predictor of math pipeline in the analysis of White student data. Therefore, the importance of academic performance for friends did not have a significant impact on the math course taking of Asian, African American, or Hispanic students overall.

School level, differential effects. The school policy of closed enrollment only had a significant impact on the course taking of White students. White students in schools without open enrollment take more high-level math courses, and the impact of SES on course taking is significantly reduced. However the effects of school policy on enrollment are not evidenced for the other racial groups. Overall, the average course taking for Asian, African American, and Hispanic students is neither significantly impacted by course enrollment policy, nor is there a significant interaction between SES and school policy.

The level of mathematics course taking varies significantly across schools for all racial groups. The effects of prior achievement on course taking are significantly different for White and African American students at different schools. Female course taking patterns only varied across schools for White students, as did the pattern of effect for the student-teacher relationship. The effect of perceived friend academic importance varied significantly across schools for African American students.

Limitations

Before discussing these findings and their implications, it is important to note limitations. First, omitted variable bias is always a limitation in a study of this nature. Although the models were developed spanning disciplines and considering a large body of prior research, it is always possible for key variables to be left out of a model or explanation. Examining the effects of other school-level variables such as school SES, school location, and school size may help to better predict student course taking. Further, this study is limited by the variables available in the ELS: 2002 data set. Selected based on the findings of previous research, the variables appear to measure the constructs of interest; however, I can only select from the variables available and interpret their meanings based on the limited information provided by NCES and the questions themselves. For example, the school-level variable of course selection also contained information about grouping and differential curriculum. It is possible these elements confounded results. For this study's purpose it would be best to have two questions for the administrator: (1) Does your school have open enrollment for core courses? (2) Is the curriculum of core courses differentiated by ability level? However, with only one question available, the answers had to be recoded to represent open versus closed enrollment.

Next, there is reason to be concerned by number of missing cases in this study. Examining data over two waves using a multilevel analysis, cases were eliminated. Although for the SEM model, data imputation procedures were used, it is possible these imputation procedures in SEM analyses and missing cases in HLM analyses would affect the results if included in the analyses.

Another limitation of this study is the reliance on self-report data. All coping resource variables, including parent, teacher, and peer factors, as well as self-efficacy were responses on the student survey. With a self-report instrument, students' reports of home and school life are situational, and therefore the current home-life situation affects the response consistency. Furthermore, with self-report, social desirability response bias is of particular concern especially when reporting on the quality of teachers and the importance of grades to peers.

Although there are limitations to the quantitative study of social factors influencing student academic decision making, there is a need to better understand how students are influenced to take higher level mathematics courses and select college majors especially students from underrepresented populations in the STEM fields. Large-scale studies, such as the one presented here, can show us patterns of behavior but are vulnerable to criticism for the oversimplification of complex social and cultural systems. Therefore, research of this nature should be complimented by more in-depth studies in which researchers can carefully document student decision making processes in their academics and the individuals involved in those decisions. Although the measures in this study clearly show differences in mathematics course taking and STEM matriculation for students with higher coping resources the direct effects of student-teacher, parent-child and peer-student interactions must be inferred.

Furthermore, when considering the impact of prior achievement, teachers, parents, peers, and efficacy beliefs, it is difficult to determine whether students enrolled in higher level courses because of their social support and high self-efficacy or whether they experience higher levels of social support for their academics as well as high efficacy because they have been successful in math previously. It is possible the behavior patterns of others as well as self are developed based on academic success achieved earlier in a student's academic career. Although this study attempted to control for prior achievement using the earliest achievement score available (10^{th} grade), it is possible achievement in elementary and middle school sets the stage for math course taking prior to high school.

Another significant limitation of this study is the lack of control for differences in course offerings between schools. Research has found schools make assumptions about the abilities and needs of their student population thus guiding decisions about course-offerings (Oakes, Selvin, Karoly, & Guiton, 1992). Therefore, schools with lower-income student populations generally have more limited offerings of advanced science and mathematics courses (Oakes, 1990; Spade, Columba, & Vanfossen, 1997). Regardless of the effects of the variables tested in this study, if a school does not offer high-level math courses, a high score on the math pipeline measure is impossible.

Discussion

The results of this study contribute to a growing research base about students' decisions to enter a STEM field, and the implications for groups underrepresented in these fields. The findings have theoretical and practical implications for high school teachers, administrators, and parents. From a theoretical perspective, the models elucidate the relationships between social resources, self-efficacy, the math pipeline, and STEM matriculation. Further, the models may provide guidance on how social resources and self-efficacy can be developed to increase the diversity of students entering the STEM fields.

The results from the analyses specific to STEM matriculation show consistent trends in selection of STEM major with students from low SES backgrounds, females, and students from underrepresented racial groups less likely than high SES students, males, and White or Asian students to have declared a STEM major in 2006. Supporting previous research findings that suggest math course taking creates a pathway to careers in math and science, this study's results show math course taking is a significant predictor of STEM matriculation.

The large magnitude of direct and indirect effects of math prior achievement on coping resources, as well as course taking and STEM major, suggest the math pipeline begins prior to high school with instruction in middle school and elementary school having a significant impact on math achievement with this achievement having lasting effects on course taking. This finding adds to past research on course taking that found the hierarchical nature of math course taking creates an advantage for students who begin high school taking higher-level courses (Schneider, Swanson, & Riegle-Crumb, 1998). Also, it is possible mathematics prior achievement is the indicator in the models most affected by stereotype threat. Based on the work of Steel and Aronson (1995), stereotype threat arises from a situation in which a negative stereotype about one's group applies. If the student fears being reduced to that stereotype by others in a situation, the emotional reaction caused can directly interfere with performance (O'Brien & Crandall, 2003; Osborne, 2001; Spencer, Steele, & Quinn, 1997; Steel & Aronson, 1995). With stereotype consciousness found to develop rapidly in middle childhood (ages 6-10), and stereotype awareness even more pronounced in students whose race and gender carry a negative stereotype (McKown & Weinstein, 2003), students at the elementary level may expect others to be judging them based on these stereotypes and underperform. Therefore, the need for mathematics preparation, especially for groups underrepresented in STEM fields, extends beyond high school to early education. The ELS: 2002 data does not allow for the examination of schooling prior to high school; therefore, further examination of the long-term effects of math achievement in elementary and middle school into high school is needed using more comprehensive national data.

The social support the resources of parents, teachers, and friends provide was not as consistent as many previous research findings of the significant role parents and teachers play in student course taking decisions. For the structural model for STEM matriculation, it was perceived importance of academic behaviors for friends that had the largest impact on math pipeline and selection of STEM major. This finding supports previous research findings of Horn and Chen (1998) who found students were more likely to enroll in college if most of their friends were planning to attend a four-year college. Students who reported attending class, good grades, and attending school after high school graduation were important to there friends took more high-level math classes in high school and were more likely to declare a STEM major in college. However, for the HLM model, the effects of parent factor were estimated before peer factor. Estimating the effects of peer academic importance controlling for the frequency of student-parent discussions demonstrated the importance of the parent-child relationship and illuminated the collinearity of these factors. Students who report more frequent academic discussions with their parents are also reporting academic behaviors are more important to their friends.

Self-efficacy plays an interesting role in math course taking and STEM matriculation. Overall, a student's beliefs about their ability to succeed on math tasks is a significant predictor of math course taking and STEM major with prior achievement and social resources leading to higher efficacy beliefs. However, females show unique relationships between these variables. Females of all races take more high-level math courses than males, but they show significantly lower math efficacy beliefs than males. Therefore, females are meeting with success in their math courses but their success is not reflected in self-beliefs about their ability in math. With math self-efficacy a significant predictor of STEM matriculation this disconnect between female achievement and efficacy beliefs may play a key role in the underrepresentation of females in STEM degrees. This finding suggests unlocking the key to math self-efficacy development holds the potential of increasing female STEM matriculation and supports the use of a symbolic interactionist approach to this issue connecting the creation of self and society. Supporting Rosenburg's work (1981) in which the self is specified as a social creation molded by interactions with others, past experiences in social contexts, and location within a social structure, the finding that females have low self-efficacy regardless of math preparation, and this negatively impacts STEM matriculation, demonstrates the self is a social product having an impact on the individual through thoughts, emotions, and behaviors.

In these ways, math self-efficacy can be viewed as a social product and a social force impacting female choice of major and career. To better understand mathematics self-efficacy as a social product and a social force, future research is needed to investigate: (1) how females and males develop their sense of self differently, (2) the critical age of self-efficacy development for females; as well as (3) key learning experiences or environmental factors that affect higher math self-efficacy in females. Although not exhaustive, this list is the beginning of future research questions investigating math self-efficacy development and the subsequent effects of different efficacy levels for females.

After examining the structure of the variables contributing to STEM matriculation, this study went further to examine the effects of school policy on the model variables. With the majority of American high schools dismantling traditional tracking procedures in the 1970s, a new era of school policy in which students could choose their courses through open-enrollment policies emerged. Lucas (1999) refers to this as “the unremarked revolution”. That is, a system of open-enrollment appears to create opportunity allowing for mobility; however, the new system has the potential to create a hidden tracking system. Additionally, international research has found educational systems that are not comprehensive, with similar courses for all students, evidenced greater segregation across fields of study (Bradley & Charles, 2004; Van Langen, Bosker, & Dekkers, 2006). With more opportunity for student choice and academic placement, there is also more opportunity for stereotyped choices as students are making important academic decisions in adolescence whey they feel the greatest pressure to conform to stereotypes. It is possible the effects of stereotype threat leading to disidentification play a role in student course-taking decisions as well. Based on these international findings, it can be argued policies of open-enrollment allowing students to choose their course-taking path hold the potential to be most detrimental for students in low-level classes, especially females and students of color.

In this study, the effects of student choice were explored on a U.S. sample comparing students within schools with open-enrollment policies to students within schools without student choice. The initial analyses, using the overall data, revealed the importance of all predictor variables to the level of math course taking except for minority race. After controlling for SES and gender, race was not a significant predictor of course taking demonstrating that students from higher socio-economic groups, regardless or race are taking more rigorous math courses in high school. Examining the role course enrollment policy played in student course taking, for the overall data, students in schools with open-enrollment policies completed a significantly lower level of courses in the math pipeline. Additionally, an open-enrollment policy increased the effect of SES on course taking. Therefore, students within open-enrollment schools chose to take less rigorous mathematics series; and, choice widened the gap in the course taking level with students from low SES backgrounds taking even fewer high-level math courses than students from higher SES backgrounds.

There are several possible explanations for these trends. First, research has shown the level of course taking upon entering high school has lasting effects on course taking throughout high school; thus, the choice young adolescents make could affect their long-term opportunities. It is likely many students at this developmental age have limited foresight, and they do not possess the knowledge or maturity to understand the long-term impacts of course decision at the beginning of high school. Continuing this line of reasoning to discuss the widening gap between low SES and high SES, with students lacking the maturity and life-lessons to make these important decisions, students with parents who had the means and opportunity to pursue higher education are more likely to insist their child take higher level math courses at the beginning of high school. Students from low SES backgrounds may not have the same guidance when selecting courses.

Another possibility is the effect of open-enrollment policy on course offerings. If students are assigned to courses, it is possible course offerings are more stable and predictable allowing for high level courses to be offered each year. Allowing students to choose courses, the school has difficulty predicting class size and staffing needs from year to year; for example, a student may register for calculus there may not be enough students to fill a class, and therefore calculus is not offered. SES has been found to play a role in course offerings as well with assumptions about the abilities and needs of their student population guiding decisions about course-offerings (Oakes, Selvin, Karoly, & Guiton, 1992). Students in lower SES schools generally have less access to advanced science and mathematics courses (Oakes, 1990; Spade, Columba, & Vanfossen, 1997). To further explore this relationship between enrollment policy and SES, examining the policy effects on schools with different SES distributions is suggested for future research. Additionally, finding a measure of school course offerings would provide a context for this study's findings, and future research could elucidate the connections between enrollment policy, SES, and course offerings.

Lucas (1999) claims a system of open-enrollment has the potential to create a hidden tracking system. A tracking system, of any kind, has the potential to promote ineffective instructional arrangements by channeling minority students into lower achieving groups or tracks (Leonard, 2001; Schumm, Moody, & Vaughn, 2000; Saleh, Lazonder, & Jong, 2005; Vanderhart, 2006). Therefore, it is important to examine the effects of course enrollment policies on students from different racial backgrounds to determine if minority students are, in fact, being channeled into less rigorous math course taking paths. I found school enrollment policy does not have the same effects on student course taking for all racial groups. In fact, only white students benefited from closed enrollment, taking more high-level math courses and SES having less of an impact on course taking. The enrollment policy did not significantly impact course taking for racial minority students, contrary to prior research finding negative impacts of tracking systems (Oakes, 1990), the course enrollment policy did not impact course taking positively or negatively. It is possible the question used to measure enrollment policy is confounding results by combining the issues of choice and differentiation. Future research is needed to better understand the role of student choice in course taking especially for minority students.

When considering race in the interpretation of other model variables, it is important to note several variables showed similar trends regardless of race. Being female, higher prior achievement, higher self-efficacy, and more frequent student-parent academic discussions were all linked to higher levels of math course taking in high school. However, different sources of teacher and peer social support are important to students of different racial groups. While all the social variables significantly impact white students, Asian and Hispanic student course taking was not significantly influenced by the reported student-teacher relationship or peer academic importance, although Asian students take more higher level mathematics courses than any other race. African American students who had higher ratings of the student-teacher relationship took significantly higher levels of mathematics; the peer factor did not have a significant effect on course taking for African American students. In practical terms I must consider the possibility that students from different racial groups respond differently to social support factors. For all students it may be beneficial to increase parent understanding of the importance of talking to their child about academic decisions more often. African American and White students may benefit from increased efforts to develop stronger student-teacher relationships. With minorities underrepresented in math and science fields it is important to examine new and different methods for increasing student course taking and considering how social capital affects racial groups differently may prove beneficial.

The methods applied here provide convincing verification of the importance of coping resources in the form of mathematics self-efficacy and social supports at the individual level. The evidence also points to the fact that there are additional influences of the school policy. Schools vary in the course taking behavior of their students. In some schools more students are taking higher level mathematics courses than in others. This reinforces previous findings that show educational opportunity is not equitable across schools. Future studies could help determine which schools are offering more opportunities for students to take higher level mathematics courses and what programs and policies have been successful in increasing the amount of mathematics studied especially by minority students.

Conclusion

This study developed a model linking coping resources in high school to mathematics course taking and subsequent enrollment in a STEM major in college considering the backgrounds of underrepresented groups. The effects of prior math achievement were felt in the relationships throughout the model. Students entering high school with lower achievement were negatively affected in social support, efficacy beliefs, course taking, and STEM matriculation. The social support of friends who value academics had the greatest impact, of the social support variables, on math course taking and subsequent STEM matriculation. Mathematics self-efficacy had a meaningful effect on higher level course taking as well as matriculation into a STEM major. Female students exhibited much lower levels of self-efficacy and STEM matriculation than males although they completed math courses at higher levels. Studies of coping resources pose interesting methodological problems in terms of gauging the situational effects on perception of social and personal variables. Future studies should attempt to further describe the development and impacts of math self-efficacy and how it differs for males and females.

The hierarchical methods used also allowed for examination of school level variables and showed significant difference between schools in student course taking behavior. An open-enrollment policy was linked to lower levels of math course taking and a larger gap in course taking between students of different socioeconomic groups. After controlling for SES, race was not a significant predictor of math course taking in high school; however, this effect varied between schools. Examining enrollment policy effects for different racial groups, White students' course taking benefited in schools with limited course enrollment. Asian, African American, and Hispanic students' course taking was not impacted by enrollment policy. Future studies should explore the policies of student choice and their impacts on academic decision making.

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APPENDIX A: IRB Permission Letter

VirginiaTech

Office of Research Compliance
Carmen T. Green, IRB Administrator
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e-mail ctgreen@vt.edu
www.irb.vt.edu
FWA00000572(expires 1/20/2010)
IRB # is IRB00000667

DATE: September 26, 2008

MEMORANDUM

TO: Mido Chang
Kimberly Filer

FROM: Carmen Green

SUBJECT: **IRB Exempt Approval:** "The Effect of Social Factors on High School Student Coursetaking and Plans to Attend College" , IRB # 08-565

I have reviewed your request to the IRB for exemption for the above referenced project. The research falls within the exempt status. Approval is granted effective as of September 26, 2008.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in the research protocol. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.

2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File

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