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College Student Pathways to the STEM Disciplines

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Article Description: This article examines the effects of individual- and institutional-level factors across secondary and postsecondary contexts on students' likelihood of majoring in the science, technology, engineering and mathematics (STEM) fields in college.

STRUCTURED ABSTRACT

Background/Context:

As concerns mount about the shortage of students entering science, technology, engineering, and math (STEM) careers, policymakers throughout the United States are contemplating strategies to maintain and enhance our nation's economic vitality and international competitiveness. Within this policy and program environment, researchers have focused considerable attention on improving STEM education at different stages of the educational pipeline, yet we lack evidence on how resources from one educational setting may influence outcomes in a successive educational setting.

Purpose/Objective/Research Question/Focus:

The purpose of the current study is to examine individual- and school-level factors that influence students' pathways to the STEM fields during college. Our research questions address the importance of high school-to-college linkages by examining students' backgrounds, aptitudes, attitudes, dispositions, and experiences in relation to majoring in a STEM field, while modeling institutional factors that comprise their secondary and postsecondary environments.

Research Design:

The study is based upon data collected through the Educational Longitudinal Study of 2002 (ELS), a national representative survey of high school sophomores who were followed through high school and into college. Students who were enrolled in a four-year institution at the end of 2006 and had declared a major were included in the analytic sample.

Analysis:

In addition to performing descriptive and factor analyses, we used cross-classified hierarchical general linear modeling as the primary analytic technique in the study.

Findings/Conclusions:

Findings from the study suggest revealed significant effects in relation to race, academic preparation, attitudes and dispositions toward math and science, college choice considerations, and postsecondary experiences. While no institutional effects were uncovered at the high school level, both postsecondary sector and selectivity significantly influenced propensities toward majoring in a STEM discipline. The study concludes with several policy recommendations related to K-16 collaborations, dual-enrollment programs, and developmental considerations for teachers and counselors working with high school students.

EXECUTIVE SUMMARY

As concerns mount about the shortage of students entering science, technology, engineering, and math (STEM) careers, policymakers throughout the United States are contemplating strategies to maintain and enhance our nation's economic vitality and international competitiveness. Preparing young adults for careers in STEM fields has received considerable attention in recent years, fueled by apprehension about producing enough students to keep up with the growing demand for an educated workforce in possession of the requisite skills utilized in STEM occupations. The prevailing concern is that a failure to meet workforce demands will ultimately impede America's ability to compete in an increasingly global and technologically advanced economy.

Influential Factors in Selecting a STEM Major

A range of explanations have been put forth by researchers to explain influential factors in students' choice of college majors, and particularly STEM fields of study. Organized into five specific areas, most studies address at least one of the following factors affecting students' choice of a STEM major in college: demographic and socioeconomic characteristics; academic preparation, attitudes, and dispositions during high school; college choice considerations, such as affordability and availability of programs; postsecondary experiences; and the academic environment defined by a variety of institutional factors.

Taking into account each of these relationships, we developed a conceptual framework for the current study based on the Student-Choice Construct, which focuses on the interactions of students within different academic environments to ultimately explain how educational opportunities unfold and educational attainment is achieved. Linkages between choice processes and educational outcomes within the Student-Choice Construct specifically address policy concerns related to areas such as access, field of study, persistence, attainment, employment, and accountability. Building on this approach, our analytic models examine high school-to-college linkages in relation to choosing a STEM major.

The Study

Despite substantial public investment in STEM programs and concern among policymakers, we have found no previous research that simultaneously incorporates secondary and postsecondary educational settings when examining STEM outcomes. While past studies have examined STEM outcomes at specific points along the K-20 continuum, we lack evidence on how resources from one educational setting may influence outcomes in a successive educational setting. With the present study we aim to contribute new information to this area of research and ultimately inform policies and practices that facilitate student pathways to STEM careers. Drawing on nationally representative data from the Educational Longitudinal Study (ELS) of 2002, we examine individual- and school-level factors that influence students' pathways to the STEM fields during college. In particular, we examine variables related to student demographics and socioeconomics, academic preparation and attitudes formed during high school, college choice considerations, and postsecondary experiences. Through multilevel modeling techniques, we

address students' academic environments during high school and college to inform both policies and practices designed to improve students' pathways to the STEM disciplines.

Methods

Data for this study was drawn from the Educational Longitudinal Study (ELS) of 2002, a survey sponsored by the Department of Education, National Center for Education Statistics (NCES), and the Institute for Education Sciences (IES). The survey was specifically designed to examine the educational transitions and work experiences of high school students, with survey administrations beginning in 2002 and continuing in 2004 and 2006. For the purposes of this study, which focuses specifically on the major declarations of students enrolled in college, we selected students based on the following two criteria: 1) students who were enrolled at a four-year, not-for-profit institution at the time of the second follow-up in 2006; and 2) students who had declared a major at the time of the second follow-up. The final analytic sample included 4,180 students attending 670 high schools and 1,050 postsecondary institutions.

The dependent variable for the study was a dichotomous measure that represented whether a student had declared a major in a STEM discipline. The following major classifications were included in the broader STEM measure: biological and biomedical sciences; computer sciences; engineering; health professions and clinical sciences; mathematics and statistics; physical sciences; and science technologies. At the student level, we included four groups of independent variables, including demographics and socioeconomics; academic preparation, attitudes, and dispositions during high school; college choice considerations; and postsecondary experiences. In addition to student level variables, we included a number of institutional factors to assess the influence of different contextual and environmental effects at the secondary and postsecondary level.

In addition to performing descriptive and factor analyses, we used cross-classified hierarchical general linear modeling as the primary analytic technique in the study. CCHGLM is a particularly useful technique when attempting to answer questions related to educational pathways as it accounts for the multiple clustering effects that occur when students transition from secondary to postsecondary institutions. In addition, CCHGLM provides important estimates of the variance that lies between high schools and postsecondary institutions, while providing an understanding of the unique and simultaneous effects of students, high schools, and postsecondary institutions. Despite the importance of controlling for institutional characteristics throughout the educational pipeline, few studies have incorporated CCHGLM techniques when documenting educational decisions. In this study, we focused on the fixed effects of students, high schools, and postsecondary institutions in understanding students pathways to STEM disciplines in college.

Findings/Conclusions

In examining student level factors that significantly influenced the odds of declaring a STEM major at the end of the second year of college, we noted an increased likelihood for Black students to enroll in a STEM discipline vis-à-vis White students. Descriptively, however, Black and Hispanic are proportionally underrepresented in the STEM fields, and this finding is

consonant with research suggesting that racial/ethnic minority groups tend to major in fields with lower earning returns. Additionally, STEM majors were associated with significantly lower SES composite scores compared to non-STEM majors, although SES did not significantly influence the likelihood of majoring in a STEM field. We also uncovered a number of highly significant effects related to students' high school preparation and STEM attitudes and dispositions. Course-taking, in particular, proved to be an extremely important factor in raising STEM propensities.

In examining postsecondary experiences, we found continued evidence that postsecondary preparation in mathematics and science coursework is essential in widening the conduit to STEM fields. Our results, however, also demonstrate the negative impact that extracurricular activities have on students' likelihood of majoring in a STEM field. Given the value that extracurricular activities can have in exposing students to new perspectives and opportunities, more attention is needed in understanding how to provide STEM students with more balanced alternatives while in college.

There are a number of policy implications based on the findings from this study. First and foremost, there is a continued need to address STEM preparation as a pipeline issue that involves key stakeholders across all levels of education. While a majority of states have developed P-16 leadership councils, the findings from this study point to the contributions of both secondary and postsecondary education in enhancing the likelihood of majoring in a STEM field, and underscore the need to address issues related to curricular alignment, proficiency standards, and college readiness from a holistic educational perspective.

In addition to developing and strengthening K-16 partnerships, the findings from this study also support the further development of dual-enrollment programs in high schools. Both the actual performance and retrospective evaluation of students' preparation in math and science point to the importance of providing students with opportunities to gain exposure to advanced math and science courses that are aligned with the expectations of college-level courses. Finally, there are important policy levers related to teachers and counselors. Students who develop an early interest in mathematics are more likely to pursue a STEM major, highlighting the importance of professional development policies and resource banks that move teachers away from rote learning mechanisms to new pedagogical innovations that emphasize inquiry-based learning infused with creativity and real world problem-solving. Among high school counselors there is also a need to advance their training and knowledge to better understand the importance of the college choice process in facilitating STEM interests, particularly educating students about STEM programs and opportunities to obtain financial aid to offset the costs of a college education.

Through an improved understanding of factors affecting STEM education at the postsecondary level, we are better situated to develop policies and practices that promote a scientifically- and technologically-advanced workforce of future researchers and scientists. This information can be used to design effective interventions that strengthen the postsecondary pipeline while improving the educational and socioeconomic opportunity for all students. Results from this study mark an important step in that direction and emphasize the importance of utilizing modeling techniques that account for individual and multiple contextual factors throughout the educational pipeline.

COLLEGE STUDENT PATHWAYS TO THE STEM DISCIPLINES

As concerns mount about the shortage of students entering science, technology, engineering, and math (STEM) careers, policymakers throughout the United States are contemplating strategies to maintain and enhance our nation's economic vitality and international competitiveness. Preparing young adults for careers in STEM fields has received considerable attention in recent years, fueled by apprehension about producing enough students to keep up with the growing demand for an educated workforce in possession of the requisite skills utilized in STEM occupations (Coble & Allen, 2005; IHEP, 2009). The prevailing concern is that a failure to meet workforce demands will ultimately impede America's ability to compete in an increasingly global and technologically advanced economy (Anderson & Kim, 2006; Chen & Weko, 2009; Dowd, Malcom, & Bensimon, 2009).

In a joint report to Congress, the National Academy of Science, the National Academy of Engineering, and the Institute of Medicine produced a set of recommendations to enhance the science and technology enterprise in the United States and ultimately guide federal policymaking in the 21st century (COSEPUP, 2007). This effort resulted in several recommendations and action items targeting STEM education in the United States. At the K-12 level, recommendations focused on recruiting and training more science and math teachers and increasing secondary education programs that prepare students to enter college and graduate in STEM disciplines. At the postsecondary level, recommendations highlighted the need to expand competitive scholarship programs to increase the rates by which U.S. citizens earn bachelor's degrees and pursue graduate degrees in the STEM fields (COSEPUP, 2007).

Against this backdrop, President Obama recently announced ambitious plans to expand the "Educate to Innovate" program to include public-private partnerships that broadly increase

the nation's focus on improving STEM education in the United States (White House, 2010).

Concurrently, state agencies and private foundations continue to focus on strategies to improve

the overall quality of the American educational system and better prepare future scientists for the

challenges of the 21st century (NCSL, 2008). Some states, for instance, have created specialized

STEM schools (Subotnik, Tai, Rickoff, & Almarode, 2010; Thomas & Williams, 2010), while

other states have ramped up the public funds invested in STEM education. In Ohio, for example,

Governor Ted Strickland and key congressional leaders have invested more than $200 million to

develop a STEM program that targets key points along the K-20 education continuum (Ohio

STEM, 2008). Accompanying these federal and state efforts have been a variety of large-scale

national scholarship programs designed to attract academically accomplished but traditionally

underrepresented students to the STEM fields during college and into graduate school (e.g., The

Gates Millennium Scholar Program; The Society of Women Engineers; NSF's S-STEM and

Graduate Research Fellowship Programs).

Within this policy and program environment, researchers have focused considerable

attention on improving STEM education at different stages of the educational pipeline,

including: the kinds of educational settings and student qualities that enhance math and science

outcomes during primary and secondary grades (Britner, 2008; Feldhusen & Jarwan, 1995; Lee,

2002; Tai, Liu, Maltese, & Fan, 2006; Webb, Lubinski, & Benbow, 2002); access, persistence,

and success of women and racial/ethnic minorities in STEM fields during college (Crisp, Nora,

& Taggart 2009; Dowd, et al., 2009; Fenske, Porter, & DuBrock, 2000; Griffith, 2010; Hanson,

2004; Hilton & Lee, 1988; Kienzl, George-Jackson, & Trent, 2009; Oakes, 1990; Rask, 2010);

and the effectiveness of advanced training and graduate level programs aimed at developing a

scientific workforce (Breneman, 1976; Clotfelter, Ehrenberg, Getz, & Siegfried, 1991;

Ehrenberg, Jakubsen, Groen, So, & Price, 2007). The resulting body of evidence demonstrates the confluence of individual and institutional factors that affect students' decisions to enter STEM disciplines.

Although there is encouraging evidence of declining gaps between white and racial/ethnic minorities interested in studying STEM fields (HERI, 2010) and increasing percentages of women and minorities entering STEM occupations, data continue to show gender and racial/ethnic gaps in bachelor's degree completion rates within STEM fields (Huang, Taddese, & Walter, 2000; Rask, 2010). Explanations of differences in the likelihood of entering STEM occupations following college have included supply-side factors related to initial choice of college major and major field persistence during college (Chen & Weko, 2009; Huang, et al, 2000). These studies have been supported by evidence of particularly high dropout rates within STEM fields among underrepresented racial/ethnic minorities (Rask, 2010), and underscore the importance of continuing investigations into those factors that promote STEM participation across the educational pipeline.

The Study

Despite substantial public investment in STEM programs and concern among policymakers, we have found no previous research that simultaneously incorporates secondary and postsecondary educational settings when examining STEM outcomes. While past studies have examined STEM outcomes at specific points along the K-20 continuum, we lack evidence on how resources from one educational setting may influence outcomes in a successive educational setting. We believe such an analysis is critical for understanding educational trajectories and student outcomes, and agree with Maple and Stage's (1991) conclusion that high school-to-college linkages represent "a seldom discussed transition point at which the pipeline

could be augmented" (p.56). With the present study we aim to contribute new information to this area of research and ultimately inform policies and practices that facilitate student pathways to STEM careers.

Drawing on nationally representative data from the Educational Longitudinal Study (ELS) of 2002, we examine individual and school level factors that influence students' pathways to the STEM fields during college. In doing so, we empirically examine the impact that students' backgrounds, academic experiences, and attitudes have on their likelihood of selecting a STEM major in college. At the center of our study is the notion that students are nested within educational institutions (e.g., Alexander & Eckland, 1977; Coleman, et al., 1966; Engberg & Wolniak, 2010), and the assumption that students' exposure to resources vary according to the characteristics of their educational settings. Thus, we also assess the effects of secondary and postsecondary institutional contexts on selecting a STEM field of study.

By focusing holistically on student pathways from high school to college into the STEM disciplines, we provide empirical evidence to inform policies and practices aimed at increasing the number of STEM majors in the United States. Our analyses were designed to answer the following two research questions:

Question 1

What individual factors affect students' likelihood of majoring in a STEM field in college, controlling for differences in the characteristics of institutions attended during high school and college? In answering this question, we examine the influence of student demographics and socioeconomics, precollege academic preparation, STEM attitudinal and dispositional traits, college choice considerations, and postsecondary experiences on the selection of a STEM field of study during college.

Question 2

What institutional factors affect students' likelihood of majoring in a STEM field in college, controlling for differences in student characteristics? In answering this question, we acknowledge that students are nested within different educational contexts, and that educational outcomes are best understood according to both individual and institutional level effects. Intuitional level measures used to address this question represent high school characteristics and the overall learning environment, as well as the selectivity and type of college attended.

Influential Factors in Selecting a STEM Major

A range of explanations have been put forth by researchers to explain influential factors in students' choice of college majors, and particularly STEM fields of study. Organized into five specific areas, most studies address at least one of the following factors affecting students' choice of a STEM major in college: demographic and socioeconomic characteristics; academic preparation, attitudes, and dispositions during high school; college choice considerations, such as affordability and availability of programs; postsecondary experiences; and the academic environment defined by a variety of institutional factors. In this section, we summarize evidence from each area.

Demographics and Socioeconomics

Studies examining differences among gender and racial/ethnic groups in choosing STEM majors in college have consistently found that women and traditionally underrepresented students of color enter the sciences and engineering fields at rates significantly below male and white students (e.g., Frehill, 1997; Hagedorn, Nora, & Pascarella, 1996; Kienzl, et al., 2009; Maple & Stage, 1991; Oakes, 1990; Sax, 2000). Evidence also suggests the presence of gender-race interactions. Among females, African Americans enter STEM majors at roughly two times

the rate of their white counterparts; among males, Asians select STEM majors at higher rates than other racial/ethnic groups (Hanson, 2004; Trusty, 2002).

In relation to SES, evidence indicates that students' selection of a college major in general, and particularly for technical and applied fields, is influenced by parents' education, occupation, and income levels (Leslie, McClure, & Oaxaca, 1998; Smart, 1988). However, mixed evidence suggests that the direction of the influence varies according to the gender and race/ethnicity of the student, and whether the measures are mother or father specific (Maple & Stage, 1991; Trusty, 2002).

Academic Preparation, Attitudes, and Dispositions during High School

One of the strongest predictors of entering a STEM disciplines is academic preparation, as measured by course-taking patterns, performance, and access to a coherent math and science curriculum (Crisp, et al., 2009; Freehill, 1997; Levine & Wycokoff, 1991; Song & Glick, 2004). In addition to measures of academic preparation, numerous studies have shown the significant role that self-efficacy plays in determining major choice, based primarily on the notion that students tend to select a subject concentration based on the expectation that they will succeed in that subject (Astin 1993; Britner, 2008; Eccles, 1987; Hackett & Betz, 1989; Lent, et al., 2008; Porter & Umbach, 2006). Maple and Stage (1991) found that attitudes towards math predicted majoring in a quantitative major within the first two years of college for some but not all student subgroups.

College Choice Considerations

Paulsen and St. John's (2002) "financial nexus" model presents financial aid and college choice measures as influential in shaping a range of students' educational choices, including college major. In a recent study of students at Hispanic Serving Institutions, Crisp, et al. (2009)

suggested that the availability of financial resources was a conceptually important "environmental pull factor" affecting students' choice of a STEM major, while other researchers included financial aid measures alongside other institutional attributes, such as college size and location, in models related to major selection (e.g., George-Jackson, Kienzl, & Trent, 2008; Smart, 1998).

Postsecondary Experiences

Students are members of communities comprised of academic and social experiences and the overall campus atmosphere. Smart, Feldman, and Ethington (2000) advanced this notion by examining the importance of students' interactions with their sub-environments in understanding a host of college outcomes. Subsequently, researchers have examined college majors based on measures of student-environment fit that are rooted in Holland's (1985) theory of vocational behavior (Porter & Umbach, 2006). Other researchers have identified the significance of more general measures of college involvement in relation to field-specific career aspirations (Sax & Bryant, 2006). Together, these studies provide the conceptual basis to examine whether the decision to major in a STEM field is associated with experiences during college, particularly the extent to which a student engages with his or her surroundings.

Institutional Factors

The literature also indicates that pathways to STEM fields in college are influenced by institutional characteristics at both secondary and postsecondary levels. At the high school level, evidence has shown the importance of the structure of organizations, social resources based on parental involvement and peer interactions, and networks of secondary and postsecondary institutions. For example, lack of educational technology (e.g., computers, calculators, and other tools for math and science) has been shown to inhibit participation in the STEM disciplines

(Tomas Rivera Policy Institute, 2008). Additionally, research has demonstrated the importance of different school resources (e.g., guidance counseling and parental involvement) on students' pathways to postsecondary education, which has direct implications on their likelihood of entering into STEM fields (Engberg & Wolniak, 2010; McDonough, 1997: Perna & Titus, 2005).

At the postsecondary level, studies have explored factors associated with selecting a STEM major among minority populations (Trent, Nicholson, & McKillip, 2006), demonstrating the importance of institutional type on majoring in a STEM field. Based on their analyses of data from the Gates Millennium Scholars program, Trent et al. (2006) reported that majoring in STEM fields among minority students was more prevalent at non-white serving institutions (i.e. Historically Black Colleges and Universities, Tribal colleges, and Hispanic Serving Institutions) than among students at predominately white institutions. Percentages of students majoring in STEM fields were also higher at public institutions compared to private institutions.

Conceptual Framework

Based on the evidence from the above research, majoring in a STEM field in college is the result of an array of students' academic achievements, attitudes and family characteristics, as well as their educational contexts in high school and into college. Taking into account each of these relationships, we developed a conceptual framework for the current study based on St. John, Asker, and Hu's (2001) Student-Choice Construct, which "provides an integrated way of viewing the linkages between student outcomes and institutional, state, and federal policies related to academics…as well as to resource management and the financing of postsecondary education" (p. 425). The Student-Choice Construct focuses on the interactions of students within different academic environments to ultimately explain how educational opportunities unfold and educational attainment is achieved. Linkages between choice processes and educational

outcomes within the Student-Choice Construct specifically address policy concerns related to areas such as access, field of study, persistence, attainment, employment, and accountability. Building on this approach, our analytic models examine high school-to-college linkages in relation to choosing a STEM major. In particular, we examine variables related to student demographics and socioeconomics, academic preparation and attitudes formed during high school, college choice considerations, and postsecondary experiences. Through multilevel modeling techniques, we address students' academic environments during high school and college to inform both policies and practices designed to improve students' pathways to the STEM disciplines.

Methods

Dataset and Analytic Sample

In answering the study's research questions, we relied on data from the Educational Longitudinal Study (ELS) of 2002, a survey sponsored by the Department of Education, National Center for Education Statistics (NCES), and the Institute for Education Sciences (IES). The survey was specifically designed to examine the educational transitions and work experiences of high school students, with survey administrations beginning in 2002 and continuing in 2004 and 2006. The ELS incorporated a multi-stage research design in which high schools were first selected based on region, urbanicity, and school control followed by a random selection of approximately 26 students per school. In addition to student respondents, the ELS also included information from parents, teachers, librarians, and high school administrators. Supplemental information was also gathered from the high school transcripts of student respondents, Free Application for Federal Student Aid (FAFSA), and the Integrated Postsecondary Education Data System (IPEDS).

For the purposes of this study, which focuses specifically on the major declarations of students enrolled in college, we selected students based on the following two criteria: 1) students who were enrolled at a four-year, not-for-profit institution at the time of the second follow-up in 2006; and 2) students who had declared a major at the time of the second follow-up. Based on these two criteria, we also eliminated high schools from the sample that had fewer than five students in order to minimize external validity issues that can occur when employing multi-level modeling. The final analytic sample included 4,180 students attending 670 high schools and 1,050 postsecondary institutions.

Variables in the Study

The dependent variable for the study was a dichotomous measure that represented whether a student had declared a major in a STEM discipline. The following major classifications were included in the broader STEM measure: biological and biomedical sciences; computer sciences; engineering; health professions and clinical sciences; mathematics and statistics; physical sciences; and science technologies.

At the student level, we included four groups of independent variables: demographics and socioeconomics; academic preparation, attitudes, and dispositions during high school; college choice considerations; and postsecondary experiences. In addition to student level variables, we included a number of institutional factors to assess the influence of different contextual and environmental effects at the secondary and postsecondary level. The high school level variables were based on the ELS administrator survey and the postsecondary variables were based on IPEDS and Carnegie Classification data.

Demographics and Socioeconomics. We included three sets of demographic variables representing gender, race, and socioeconomic status (SES). Gender and race variables were

entered as dummy variables, with males and White students serving as referent groups, respectively. We used the standardized SES composite index contained in the ELS dataset, which incorporates measures of parental attainment, parental occupation, and total income. In using this composite measure over individual covariates, we were able to minimize multicollinearity issues and suppression effects that commonly occur when including highly correlated measures in the same analysis.

Academic Preparation, Attitudes, and Dispositions during High School. We used two continuous measures—high school grade point average (GPA) and highest level of math and science courses—to examine students' academic preparation in high school. High school GPA was measured on a standard four-point scale. In order to compute the highest level of math and science courses, we took the mean of two variables that measured course-taking based on an eight-point Likert scale. For the math measure, the scale ranged from a low of no math course to a high of advanced calculus. For the science measure, the scale ranged from a low of no science course to a high of advanced physics and chemistry.

In terms of STEM dispositions, we included three variables to capture student's interest, self-efficacy, and engagement in mathematics during high school. The interest in math scale was based on a mean of two Likert-type items that measured students' level of agreement that math was both fun and important. The self-efficacy scale was derived using factor analytic procedures and included five items that measured the extent to which students were able to master math skills, do excellent on math tests and assignments, and understand difficult math texts and classes (Alpha=.913). The math engagement scale was a behaviorally-based measure that averaged the number of hours in which students worked on math homework inside and outside of school.

College Choice Considerations. To capture how aspects of the college choice process influence later STEM decisions, we included a measure related to affordability and five dichotomous variables that assessed factors used in making college choice decisions. The college affordability measure was based on the average of two items that assessed the importance of postsecondary financial aid and low postsecondary school expenses. The college choice variables asked students whether they chose their college based on program, reputation, cost, location, or personal/family reasons.

Postsecondary Experiences. In order to examine postsecondary experiences that potentially influence college major decisions, we included six variables that measured students' postsecondary preparation in math and science and their engagement in academic and non-academic pursuits. The postsecondary preparation measure was an average of two variables that asked students' to rate the extent to which their high school prepared them for college-level courses in math and science. The other postsecondary variables asked students to rate the frequency in which they met faculty outside of class to discuss academics, met with an advisor about academic plans, worked on classwork at the library, used the web to access the library for coursework, and participated in extracurricular activities.

Institutional Factors. The high school level variables included two sets of dummy variables to capture the sector (i.e., public, Catholic, and other private schools) and region (urban, suburban, and rural) of the high school. Additionally, we used two single-item variables that assessed the extent to which the high school helped students select majors/career pathways and the extent to which students were involved in college preparation programs. We also included three scales derived through factor analysis to measure the overall learning environment. The first scale examined the extent to which learning was hindered based on the

lack of computers, multimedia, and other technological equipment (Alpha=.780). The second scale examined the extent to which learning was hindered based on the poor condition of the building, science labs, library, and other learning spaces (Alpha=.884). The final measure was a continuous variable that assessed the percentage of math and science teachers in a particular school.

In order to capture aspects of the postsecondary environment, we included variables to control for the sector (public versus private) and selectivity of the institution. The selectivity measure was based on the Carnegie Foundation's Undergraduate Profile Classification, which uses SAT and ACT score distributions (e.g., 75th and above, 25th - 75th, and 25th and below) to derive a classification of highly selective, moderately selective, and inclusive four-year institutions, respectively. Additionally, because approximately 11 percent of the schools were missing a classification score, we included a fourth, unknown category; this category most likely represents schools that do not require standardized tests in the admissions process.

Analytic Approach

In addition to performing descriptive and factor analyses, we used cross-classified hierarchical general linear modeling (CCHGLM; Raudenbush & Bryk, 2002) as the primary analytic technique in the study. CCHGLM is a particularly useful technique when attempting to answer questions related to educational pathways as it accounts for the multiple clustering effects that occur when students transition from secondary to postsecondary institutions. In addition, CCHGLM provides important estimates of the variance that lies between high schools and postsecondary institutions, while providing an understanding of the unique and simultaneous effects of students, high schools, and postsecondary institutions. Despite the importance of controlling for institutional characteristics throughout the educational pipeline, few studies have

incorporated CCHGLM techniques when documenting educational decisions. In this study, we focused on the fixed effects of students, high schools, and postsecondary institutions in understanding students pathways to STEM disciplines in college.

Due to the dichotomous nature of the STEM outcome measure, the level-1 model is based on a Bernoulli (0-1) distribution. We first ran a fully unconditional CCHGLM model to develop a baseline understanding of high school and postsecondary variance components. Unlike HLM models that use a linear outcome and rely on an interclass correlation (ICC) to understand the amount of variance explained at Level 2, the non-normal distribution of the variance of Bernoulli outcomes requires the use of alternative methods. In this study, we examined the significance levels of the variance components in the fully unconditional model as well as the box-plots of the Empirical Bayes (EB) residuals to determine the extent of variation across high schools and postsecondary institutions. The fully unconditional model is expressed by the following two equations:

Level 1 Fully Unconditional Model:

$$Yijk = \pi_{0jk} + e_{ijk}, \qquad e_{ijk} \sim N(0, \sigma^2)$$

where *Yijk* represents the likelihood of entering a STEM major for student *i* in high school *j* and postsecondary institution *k*; π_{0jk} is the average likelihood of declaring a STEM major for students who attend high school *i* and postsecondary institution *k*; and σ^2 is the within-cell variance.

Level 2 Fully Unconditional Model:

$$\pi_{0jk} = \theta_0 + b_{00j} + c_{00k}, \qquad b_{00j} \sim N(0, \tau_{b00}), c_{00k} \sim N(0, \tau_{c00}),$$

where θ_0 is the grand mean of declaring a STEM major, b_{00j} and c_{00j} represent the random main effect of high school *j* and postsecondary institution *k*, respectively.

Upon finding significant variation across high schools and postsecondary institutions, we proceeded to run the conditional model in which Level 1 and 2 covariates were simultaneously entered into the model. This model is expressed by the following equations:

Level 1 Conditional Model:

$Yijk = \pi_{0jk} + \pi_{1jk}$(Demographics and Socioeconomics)$_{1jk} + \pi_{2jk}$(Academic Preparation, Attitudes, and Dispositions during High School)$_{2jk} + \pi_{3jk}$(College Choice Considerations)$_{3jk} + \pi_{4jk}$(Postsecondary Experiences)$_{4jk} + e_{ijk}$,

where π_{0jk} represents the average likelihood of declaring a STEM major for students who attend high school i and postsecondary institution k, and π_{1-4} corresponds to the fixed effect of each student level group of variables on an individual's likelihood of declaring a STEM major.

Level 2 Conditional Model:

$\pi_{0jk} = \theta_0 + \gamma_{01}$ (High School Level Variables)$_j + \beta_{01}$(College Level Variables)$_k + b_{00j} + c_{00j}$,

where γ represents the fixed effect of any high school level variable at high school $_j$, and β represents the fixed effect of any postsecondary level variable at college $_k$, and b_{00j} and c_{00j} represent the residual random effects of high schools and postsecondary institutions, respectively, on π_{0jk} after controlling for all other covariates in the model.

Using the recommendations by Raudenbush and Bryk (2002), all continuous variables in the model were grand-mean centered. This technique allows for the interpretation of model parameters in relation to the average student in the sample declaring a STEM major.

Limitations

There are several limitations in this study. First, the sample used in this study only includes students who declared a major by the time of the second follow-up survey administration, and excludes those students who were undecided. Additionally, some schools were excluded from the analyses based on too few students representing a particular school (i.e., less than five). While these decisions were necessary in ensuring the integrity of our analyses, we recognize that they pose some threats to the external validity of the results. Second, we were

constrained by the nature of the data collected through the ELS and recognize that additional covariates, particularly at the postsecondary level, may be important in explaining STEM major decisions. Third, although the ELS data represents one of the most current and complex data sources to study student transitions across the secondary-postsecondary nexus, we recognize that the data reflect an earlier cohort of high school students and cohort changes in recent years may limit the generalizability of the study's results. Fourth, while understanding factors that influence students' likelihood of selecting a STEM major in college is critically important for strengthening the pipeline of individuals into the STEM workforce, majoring in a STEM field during college does not necessarily lead to career in the math, science, or technical fields. The next wave of ELS data, scheduled for release in 2012, will provide additional information to examine the extent to which STEM majors select into different occupational fields and enter into graduate and professional educational programs. Fifth, we recognize there may be more nuanced differences in enrollment propensities within the various STEM fields, and further studies are planned to better understand these disciplinary nuances. Sixth, we were unable to test for interaction effects at the school level due to the small number of cases in the high school by postsecondary institution matrix. CCHGLM, however, requires a certain amount of parsimony given the complexity of this modeling technique, and we made very deliberate and empirically-justified decisions in terms of which variables to include in the model. We recognize that other researchers may prefer alternative approaches to operationalizing some of the key constructs we have included in our analytic model.

Results

Descriptive Results

Table 1 presents descriptive statistics for all variables in the student level model, including the total sample and the sample bifurcated by STEM major classification. Additionally, we performed independent t-test results on all variables in the analysis across STEM and non-STEM classifications. Female students were more highly represented in the non-STEM versus STEM majors (58% versus 52%), although both samples favored females. In examining racial differences, Asian, Black, and unknown students represented a significantly higher proportion of students in the STEM majors, whereas White students had a significantly lower proportional representation. Additionally, STEM majors were associated with a significantly lower average SES (.43) compared to non-STEM majors (.46).

<<INSERT TABLE 1 HERE>>

In terms of academic preparation, STEM majors were associated with significantly higher mean scores in relation to both high school GPA and the highest level of math/science course-taking compared to non-STEM majors. Similarly, when examining STEM attitudes and dispositions, STEM majors were associated with significantly higher scores. Students entering the STEM disciplines, therefore, demonstrate higher levels of achievement in high school, greater interest and self-efficacy in relation to mathematics, and study mathematics more often inside and outside of class.

In examining college choice considerations, STEM majors placed a significantly higher level of importance on college affordability and financial aid availability compared to non-STEM majors (2.36 versus 2.30). In terms of different factors that influence college choice decisions, a significantly higher percentage of STEM majors (71% versus 60%) indicated that the program offered at a college was an important consideration compared to non-STEM majors. Conversely, a significantly higher proportion of non-STEM majors (32% versus 28%) chose

their college based on family and personal reasons compared to STEM majors. The remaining college choice considerations were relatively similar across groups.

STEM majors were also associated with the highest average scores in relation to their postsecondary preparation for math and science courses. Similarly, STEM majors were represented by significantly higher scores in relation to their frequency of working on coursework at the library. While STEM majors appear more academically engaged, non-STEM majors were associated with significantly higher participation levels in extracurricular activities.

Finally, in examining the various institutional characteristics of the sample (see Table 2), the majority of the high schools were public, with more variation found in relation to urbanicity. On average, 24% of the teachers in the high school sample taught in math or science. The postsecondary institutions were represented by a slightly higher proportion of private schools over public schools (56% versus 44%), and were associated with the highest proportion of schools (47%) in the moderately selective range.

<<INSERT TABLE 2 HERE>>

CCHGLM Results

The CCHGLM provides unit specific information about the effects of individual and school level factors on the likelihood of majoring in a STEM discipline. We began this analytic process by first analyzing the level 2 variance components of the fully unconditional model. We found significant variance at both the high school ($b_{00} = .102$, $p < .05$) and postsecondary ($c_{00} = .192$, $p < .001$) levels, which complemented the visual inspection of the variance found in the EB residual box plots. Thus, we found empirical justification to proceed to the conditional effects model. Like the fully unconditional model, the high school ($b_{00} = .094$, $p < .05$) and postsecondary ($c_{00} = .287$, $p < .001$) variance components were highly significant, demonstrating

that the conditional model explained 7.8% and 33.1% of the variance at the high school and postsecondary levels, respectively.

In order to interpret the individual and school level effects in the conditional model (see Table 3), we examined the odds ratios and *Delta-p* statistics for categorical and continuous variables, respectively. An odds ratio represents the change in the odds that a student declared a STEM major and is useful for interpreting the effects of belonging to one group versus a reference group for dichotomous variables. The *Delta-p* statistics represents the change in probability that a student majored in a STEM field resulting from a one-unit change in a continuous, independent variable (Long, 1997; Peterson, 1985).

In relation to demographic characteristics, we found no differences in gender but several effects for different race groups. Both Asian and Black students, for instance, were 61% and 69% were more likely to major in a STEM discipline, respectively, compared to White students; a similar albeit smaller effect was found for students with an unknown racial classification. Despite mean differences in SES across STEM and non-STEM groups, no significant effects were uncovered in the CCHGLM analysis.

All of the high school preparation and STEM dispositional variables were highly significant in the model. The strongest effect was found in relation to math/science course-taking, with each successive level associated with an 8.2% increase in the probability of declaring a STEM major. Additionally, as students' high school GPA increased, their probability of declaring a STEM major increased by 6%. The probabilities associated with the STEM attitudes and dispositions were slightly lower compared to the academic preparation variables, with math self-efficacy and interest in math associated with probabilities of 5.4% and 4.2%,

respectively. The math engagement scale, while significant, demonstrated only a 2% increase in the probability of declaring a STEM major.

<<INSERT TABLE 3 HERE>>

One of the strongest indictors of majoring in a STEM field was related to students who chose a particular college or university based on an examination of the programs offered. Students who used program information were 68% more likely to declare a STEM major versus those who did not consider program information in the college choice process. Conversely, students who chose a college or university based on either reputation or family/personal reasons were 16% less likely to choose a STEM major versus those who did not consider these factors. Finally, as students placed greater importance on college affordability and financial aid availability, they were associated with a 3.4% increase in the probability of declaring a STEM major.

A number of postsecondary experiences also proved important in understanding students' pathways to the STEM disciplines. For example, as students rated their postsecondary preparation in math and science higher, they increased their probability of majoring in a STEM field by almost 6%. Similarly, as students met more frequently with an academic advisor concerning academics or worked more frequently on coursework at the library, they were associated with increased probabilities of majoring in a STEM field by 3.6% and 3.0%, respectively. Unlike the academic engagement variables, as students participated more frequently in extracurricular activities, they were associated with lower probabilities (-5.2%) of declaring a STEM major.

Despite incorporating a number of theoretically and empirically justified high school level characteristics and environmental considerations, we did not uncover any significant effects

in the CCHGLM analysis. At the college level, however, we uncovered a number of significant effects. Attending a private postsecondary institution, for example, significantly lowered the odds of the declaring a STEM major. In addition, attending a postsecondary institution with inclusive selectively increased the likelihood of declaring a STEM major by 45% compared to those attending highly selective institutions. Finally, students attending institutions of unknown selectivity, presumably those with test-optional policies, were 55% more likely to choose a STEM major compared to those attending highly selective schools.

Discussion

Given the current state of STEM education, in which a comparatively lower percentage of students study a STEM discipline in college in relation to other countries (NCSL, 2008), there is a vital need to understand how to improve overall participation rates in the STEM disciplines. This need is reinforced by the growing concern that not enough future teachers will be trained in STEM fields, as well as the significant impact a shortage of trained STEM researchers and scientists can have on the long-term economic health and stability of the nation (Coble & Allen, 2005; IHEP, 2009). The current study addresses this concern by examining STEM participation rates across the secondary-postsecondary nexus. Toward this end, our research questions specifically examined individual and school effects at both the high school and postsecondary levels.

In examining student level factors that significantly influenced the odds of declaring a STEM major at the end of the second year of college, we noted an increased likelihood for Black students to enroll in a STEM discipline vis-à-vis White students. Descriptively, however, Black and Hispanic are proportionally underrepresented in the STEM fields, and this finding is consonant with research suggesting that racial/ethnic minority groups tend to major in fields with lower earning returns (Zhang, 2008). Additionally, STEM majors were associated with

significantly lower SES composite scores compared to non-STEM majors, although SES did not significantly influence the likelihood of majoring in a STEM field. While few studies have utilized an SES composite index that includes information pertaining to household income and parent educational and occupational attainment, earlier studies examining mother's educational attainment have noted positive relationships in relation to African American male students (Maple & Stage, 1991). Future research is needed to understand whether the effects of SES are conditional on other factors, such as race, gender, or more differentiated STEM fields.

We also uncovered a number of highly significant effects related to students' high school preparation and STEM attitudes and dispositions. Many of these effects resonate with earlier studies (Astin 1993; Eccles, 1987; Lent et al,, 1984; Levine & Wycokoff, 1991; Song & Glick, 2004) and reinforce the importance of policy interventions at the secondary level. Course-taking, in particular, proved to be an extremely important factor in raising STEM propensities, which highlights the need to provide students with appropriate guidance around course selection early on in their high school careers. Additionally, incorporating pedagogical innovations that translate learning about science and mathematics into more accessible, interesting, and real-world applications will likely yield greater interest and involvement—two factors that increase the likelihood of STEM participation.

Although college affordability can certainly inhibit postsecondary access, it does not appear to dampen students' decisions to enter into a STEM discipline; rather, the findings from this study suggest it may actually increase the propensity to enter a STEM discipline. One of the more interesting findings from this study relates to the factors students employ in deciding upon a particular college or university. The results suggest that students who take into consideration the programs offered at a particular school are much more likely to enroll in a STEM discipline.

This has broad implications for college guidance counselors and college admissions representatives, and suggests that the college search process needs to be augmented by additional presentations and materials that highlight specific programs in the STEM disciplines.

In examining postsecondary experiences, we found continued evidence that postsecondary preparation in mathematics and science coursework is essential in widening the conduit to STEM fields. More conversations are necessary that bring together representatives across the educational pipeline, as well as greater consistency and clearer expectations of the requisite skills and coursework that students need to prepare for the academic challenges they will face upon postsecondary enrollment. Additionally, more work at the college level is needed to engage students in academic planning and developing effective study habits, although this shouldn't necessarily come at the expense of opportunities to engage in the co-curriculum. With more institutions touting the importance of holistic student development and encouraging participation at both the curricular and co-curricular levels, students interested in the STEM fields are often faced with difficult tradeoffs that run counter to holistic educational missions. Our results demonstrate the negative impact that extracurricular activities have on students' likelihood of majoring in a STEM field. Given the value that extracurricular activities can have in exposing students to new perspectives and opportunities, more attention is needed in understanding how to provide STEM students with more balanced alternatives while in college.

Finally, despite the lack of findings at the high school level, more research is necessary that further investigates high school level covariates, particularly research on how high school level factors and postsecondary level factors interact with individual level preparation and dispositional traits. Although we did find evidence of postsecondary institutional effects related to both sector and selectivity, more work is necessary that investigates a larger repertoire of

contextual and environmental factors. For example, a recent study of STEM-field persistence based on two national datasets found evidence suggesting college student experiences and first year grades in STEM-related coursework are particularly important in helping students persist in STEM majors (Griffith, 2010). Interestingly, this study also indicated that students are more likely to persist in a STEM field if they attend postsecondary institutions emphasizing undergraduate teaching and research, rather than emphasizing graduate education (Griffith, 2010). With the next follow-up of the ELS slated for 2012, we hope to widen our postsecondary scope and incorporate a full range of curricular, co-curricular, and contextual variables.

Policy Implications

There are a number of policy implications based on the findings from this study. First and foremost, there is a continued need to address STEM preparation as a pipeline issue that involves key stakeholders across all levels of education. Additionally, given the rapid rate in which technological innovations fuel the need for additional workforce skills in the STEM fields, business and community leaders remain important stakeholders in developing comprehensive solutions to address the shortage of graduates both interested and equipped with the requisite skills needed in the STEM fields. While a majority of states have developed K-16 leadership councils, the findings from this study point to the contributions of both secondary and postsecondary education in enhancing the likelihood of majoring in a STEM field, and underscore the need to address issues related to curricular alignment, proficiency standards, and college readiness from a holistic educational perspective.

In addition to developing and strengthening K-16 partnerships, the findings from this study also support the further development of dual-enrollment programs in high schools. Both the actual performance and retrospective evaluation of students' preparation in math and science point to the

importance of providing students with opportunities to gain exposure to advanced math and science courses that are aligned with the expectations of college-level courses. Dual-enrollment programs, in which students are provided opportunities to take college-level courses within their high schools or a nearby college, have the potential to increase college readiness and proficiency in mathematics and science (Karp, Calcagno, Hughes, Jeong, & Bailey, 2007). Additionally, dual-enrollment programs often attract underrepresented students to the STEM fields by linking them directly to apprenticeships and easing the burden of later college costs. The cumulative effects of such programs can lead to increased savings for states in the form of lower dropout rates and reductions in the cost of remediation, while providing long-term benefits to the workforce demands of a given state (Richardson, Berns, Sandler, & Marco, 2009).

Finally, there are important policy levers related to teachers and counselors. Students who develop an early interest in mathematics are more likely to pursue a STEM major, highlighting the importance of professional development policies and resource banks that move teachers away from rote learning mechanisms to new pedagogical innovations that emphasize inquiry-based learning infused with creativity and real world problem-solving (Richardson et al., 2009). Teachers remain critical change agents in encouraging and developing future STEM interests among students, and policies are needed to incentivize teachers to expose students to the connections between coursework and occupational choices, as well as the productivity returns based on students' human capital investments . Among high school counselors there is also a need to advance their training and knowledge to better understand the importance of the college choice process in facilitating STEM interests, particularly educating students about STEM programs and opportunities to obtain financial aid to offset the costs of a college education. Policies aimed at improving the availability

and efficacy of high school counselors, however, require a commitment from stakeholders at the high school, district, college, and state levels (Perna, Rowan-Kenyon, Thomas, & Bell, 2008).

Through an improved understanding of factors affecting STEM education at the postsecondary level, we are better situated to develop policies and practices that promote a scientifically- and technologically-advanced workforce of future researchers and scientists. This information can be used to design effective interventions that strengthen the postsecondary pipeline while improving the educational and socioeconomic opportunity for all students. Results from this study mark an important step in that direction and emphasize the importance of utilizing modeling techniques that account for individual and multiple contextual factors throughout the educational pipeline.

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Table 1. Descriptive Statistics of Student Level Variables

Student Level Variables (N=4180)	Min	Max	Total (n=4180)	SD	Non-STEM (n=2840)	SD	STEM (N=1340)	SD
					Means and Standard Deviations			
STEM participation	0.00	1.00	0.32	0.47				
Female	0.00	1.00	0.56	0.50	0.58	0.49	0.52**	0.50
Male	0.00	1.00	0.44	0.50	0.42	0.49	0.48**	0.50
Asian	0.00	1.00	0.11	0.31	0.08	0.28	0.15***	0.36
Black	0.00	1.00	0.10	0.30	0.09	0.28	0.11*	0.32
Hispanic	0.00	1.00	0.08	0.26	0.08	0.27	0.06	0.25
Multi	0.00	1.00	0.04	0.19	0.04	0.19	0.04	0.19
White	0.00	1.00	0.65	0.48	0.68	0.47	0.58***	0.49
Unknown	0.00	1.00	0.04	0.19	0.03	0.18	0.05*	0.21
SES	-2.11	2.57	0.45	0.68	0.46	0.66	0.43***	0.71
GPA	0.12	4.00	3.16	0.60	3.11	0.60	3.27***	0.57
Highest level of math/science courses	1.00	8.00	6.26	1.11	6.10	1.09	6.61***	1.08
Interest in math	1.00	4.00	2.46	0.79	2.37	0.78	2.66***	0.78
Math self-efficacy	1.00	4.00	2.78	0.78	2.69	0.77	2.95***	0.76
Math engagement	1.00	9.00	3.41	1.40	3.29	1.42	3.66***	1.31
Importance of college affordability	1.00	3.00	2.32	0.60	2.30	0.61	2.36***	0.59
Chose college based on program	0.00	1.00	0.63	0.48	0.60	0.49	0.71***	0.45
Chose college based on reputation	0.00	1.00	0.63	0.48	0.63	0.48	0.63	0.48
Chose college based on cost	0.00	1.00	0.51	0.50	0.51	0.50	0.52	0.50
Chose college based on location	0.00	1.00	0.72	0.45	0.72	0.45	0.70	0.46
Chose college based on family	0.00	1.00	0.31	0.46	0.32	0.47	0.28**	0.45
Postsecondary preparation for STEM	1.00	3.00	2.36	0.54	2.32	0.54	2.46***	0.53
Met with faculty outside of class to discuss academics	1.00	3.00	2.19	0.59	2.20	0.59	2.17	0.59
Met with advisor about academic plans	1.00	3.00	2.23	0.58	2.22	0.59	2.24	0.56
Work on coursework at library	1.00	3.00	2.31	0.68	2.30	0.67	2.34*	0.69
Use web to access library for coursework	1.00	3.00	2.47	0.65	2.48	0.65	2.46	0.66
Participate in extracurricular activities	1.00	3.00	2.18	0.76	2.20	0.77	2.15*	0.76

Source: ELS: 2002 Restricted Dataset; sample sizes were rounded to nearest tenth based on ELS restricted data guidelines

*p<.05; **p<.01; ***p<.001; asterisks represent independent samples t-tests results between STEM and non-STEM majors

Table 2. Descriptive Statistics of High School and College Level Variables

	Min	Max	Mean	SD
High School Level Variables (N=670)				
Public	0.00	1.00	0.76	0.42
Catholic	0.00	1.00	0.14	0.35
Other Private	0.00	1.00	0.09	0.29
Urban	0.00	1.00	0.33	0.47
Suburban	0.00	1.00	0.48	0.50
Rural	0.00	1.00	0.19	0.39
Emphasis on majors/career pathways	1.00	3.00	2.18	0.74
Emphasis on college preparation	1.00	3.00	1.84	0.65
Learning hindered by technology	1.00	4.00	1.87	0.70
Learning hindered by equipment	1.00	3.86	1.73	0.62
School morale is high	1.20	5.00	3.95	0.63
Percentage of math/science teachers	0.00	0.70	0.24	0.07
College Level Variables (N=1050)				
Public	0.00	1.00	0.44	0.50
Private	0.00	1.00	0.56	0.50
High selectivity	0.00	1.00	0.28	0.45
Moderate selectivity	0.00	1.00	0.47	0.50
Inclusive selectivity	0.00	1.00	0.14	0.34
Unknown selectivity	0.00	1.00	0.11	0.31

Source: ELS: 2002 Restricted Dataset; sample sizes were rounded to nearest tenth based on ELS restricted data guidelines

Table 3. Results from the Cross-Classified HGLM Predicting Majoring in a STEM Discipline

	Coefficient	SE	Odds Ratio	Delta *p*	
Student Level Effects					
Demographics & Socioeconomics					
Female	-0.129	0.078	0.879	-2.7%	
Asian (White)	0.475	0.127	1.608	11.1%	***
Black (White)	0.524	0.139	1.688	12.3%	***
Hispanic (White)	-0.152	0.155	0.859	-3.2%	
Multi (White)	0.215	0.192	1.239	4.8%	
Unknown (White)	0.462	0.191	1.588	10.8%	*
SES	-0.082	0.063	0.921	-1.8%	
Academic Preparation, Attitudes, and Dispositions during High School					
GPA	0.265	0.083	1.304	6.0%	**
Highest level of math/science courses	0.356	0.045	1.428	8.2%	***
Interest in math	0.186	0.051	1.205	4.2%	***
Math self-efficacy	0.238	0.053	1.269	5.4%	***
Math engagement	0.092	0.029	1.097	2.0%	**
College Choice Considerations					
Chose college based on program	0.520	0.084	1.682	12.2%	***
Chose college based on reputation	-0.165	0.085	0.848	-3.5%	*
Chose college based on cost	-0.092	0.078	0.912	-2.0%	
Chose college based on location	-0.126	0.084	0.882	-2.7%	
Chose college based on family	-0.173	0.081	0.841	-3.6%	*
Importance of college affordability	0.151	0.068	1.163	3.4%	*
Postsecondary Experiences					
Postsecondary preparation for STEM	0.258	0.074	1.295	5.9%	***
Met faculty outside of class to discuss academics	-0.087	0.070	0.917	-1.9%	
Met with advisor about academic plans	0.160	0.071	1.173	3.6%	*
Work on coursework at library	0.134	0.059	1.143	3.0%	*
Use web to access library for coursework	-0.082	0.062	0.921	-1.8%	
Participate in extracurricular activities	-0.250	0.053	0.779	-5.2%	***

Table 3. *Continued*

	Coefficient	SE	Odds Ratio	Delta p	
High School Level Effects					
Catholic (Public)	0.134	0.119	1.144	3.0%	
Other Private (Public)	0.094	0.137	1.098	2.1%	
Suburban (Urban)	-0.071	0.092	0.932	-1.5%	
Rural (Urban)	0.016	0.132	1.016	0.4%	
Emphasis on majors/career pathways	0.048	0.058	1.049	1.1%	
Emphasis on college preparation	0.064	0.061	1.066	1.4%	
Learning hindered by technology	0.148	0.076	1.159	3.3%	
Learning hindered by equipment	-0.121	0.087	0.886	-2.6%	
School morale is high	-0.076	0.071	0.927	-1.6%	
Percentage of math/science teachers	0.560	0.578	1.751	13.2%	
College Level Effects					
Private (Public)	-0.392	0.093	0.675	-7.9%	***
Moderate selectivity (High)	0.047	0.101	1.049	1.0%	
Inclusive selectivity (High)	0.369	0.158	1.446	8.5%	*
Unknown selectivity (High)	0.440	0.178	1.553	10.2%	*
Model Statistics (Random Effect of Intercept)					
High school level variance component	0.094**				
College level variance component	0.192***				

Source: ELS: 2002 Restricted Dataset
*p<.05; **p<.01; ***p<.001; parentheses indicates referent group