Quality and Equality on the Pathway to Teaching Mathematics and Science in Texas

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This research was supported by a grant from the National Science Foundation under NSF Grant REC-0635615. This research also uses data from the Texas Higher Education Opportunity Project (THEOP) and acknowledges the following agencies that made THEOP data available through grants and support: Ford Foundation, The Andrew W. Mellon Foundation, The William and Flora Hewlett Foundation, The Spencer Foundation, National Science Foundation (NSF Grant # SES-0350990), The National Institute of Child Health & Human Development (NICHD Grant # R24 H0047879) and The Office of Population Research at Princeton University. All opinions expressed herein are of the authors, and do not necessarily reflect those of the funding agencies.

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INTRODUCTION

The pathway to teaching is a continuous cycle where aspiring teachers emerge from the K-12 system, go to college, and then return to the K-12 system to teach a new generation of students; the quality and diversity of the teaching force therefore begins with, builds on, and is limited by the available educational opportunities along that pathway. Lack of proper high school course sequencing limits student pathways to college, to majoring in mathematics or science, and to becoming mathematics or science teachers long before most consider career choices seriously.

Using two waves of restricted data from the 2002-03 Texas Higher Education Opportunity Project[1], the study determines the advantages that mathematics and science course sequences accrue to:

1) acceptance and attendance at four year colleges;
2) majoring in mathematics and science at the college level; and,
3) entering (or leaving) the pathway to teaching mathematics and science.

Key areas of interest include the ways results vary by important high school and student demographic characteristics such as socioeconomic status, gender and race/ethnicity.

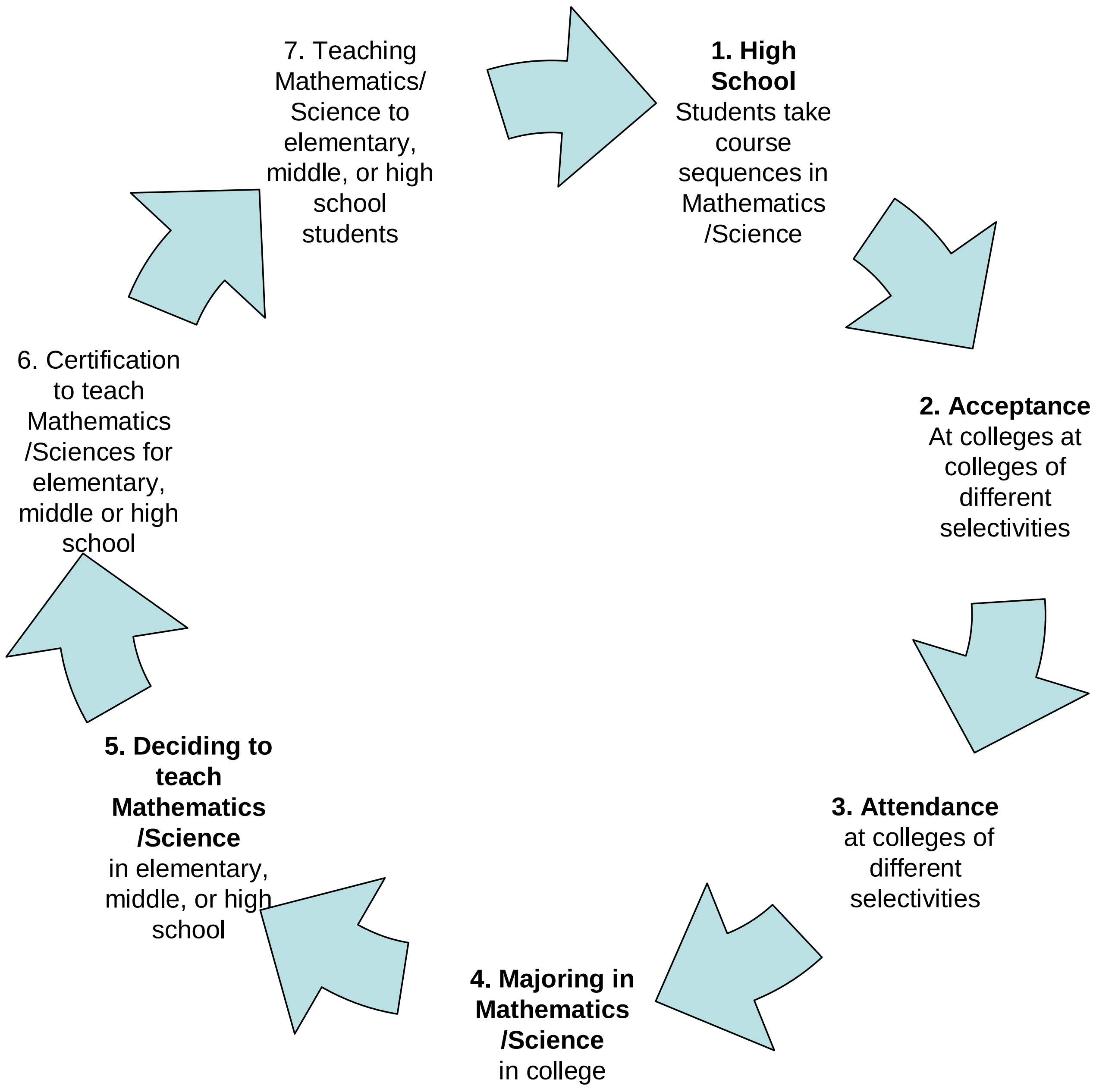
Taking higher mathematics/science course sequences in high school is related to acceptance, to attendance, to majoring in mathematics and/or science in college and ultimately determines who will be in position to choose to teach those subjects as a career. On average, White and Asian students take more rigorous high school mathematics and science course sequences than Black and Hispanic students; consequently, many Black and Hispanic students slip off the pathway to mathematics and science teaching before finishing high school. Once in a college, students' educational backgrounds and interests are more alike than in high school.

[1] See http://www.texastop10.princeton.edu/index.html

Gender rather than race/ethnicity helps to explain who majors in mathematics and science and who plans to teach those subjects. In this data, females are not only more likely to plan to teach mathematics and science, they are also more likely to declare a major in mathematics or science at sophomore year than males.

Highly qualified mathematics and science teachers are the result of fortuitous opportunities and choices available along the pathway. Studying students who opt to enter and leave the pathway to mathematics and science careers including teaching suggests strategies to increase both the quality and equality of the America's mathematics and science teachers.

Figure 1. The Pathway to Teaching



BACKGROUND:

The cycle that ends with high-quality mathematics and science teachers begins with the course sequences that aspiring teachers take in high school. Current government action is directed at both improving the quality of high school mathematics and science coursework while simultaneously encouraging students to take more science and mathematics courses. Since it is well-known that highly qualified teachers are the best predictor of student mathematics and science gains/achievement (Darling-Hammond, 2000; National Commission on Teaching and America's Future, 1996; Sanders & Rivers, 1996), the No Child Left Behind Act stipulated that teachers must major in the subject matter they teach and that all teachers must be highly-qualified by 2005-2006, a target date that all states missed. Currently all states have filed plans for meeting the requirement in the future.

In a world where mathematics and science credentials are prized and where diversity is limited, teaching is in direct competition with the more lucrative and prestigious professions. Even so, many high school students are not taking the higher course sequences that put them on track for college entry and these professions. This paper focuses on the sequential steps necessary to become a mathematics or science teacher beginning with mathematics and science course sequences in high school. It also considers how this trajectory differs for students from different demographic groups.

The synthesis of the literature for this project not only draws from research in education, but also from research in sociology, industrial and labor relations, economics, psychology, and law. The literature review considers four topic areas: course sequences, college selectivity, majoring in mathematics and science, and teaching mathematics and science. The topic areas are followed by special considerations when pursuing research on education in Texas.

Course sequences. The course sequences that students take in high school stratify students academically and qualify them for different opportunities in school and life (Stevenson, Schiller, & Schneider, 1994). Mathematics, more than other subjects, filters students out of programs that would lead to scientific and professional careers (National Research Council, 1989). When a student begins a sequence determines how far s/he can go by the end of high school (Lucas, 1999; Lucas & Berends, 2002). Those who take more rigorous sequences are more likely to attend college (Schneider, 1998) and ultimately to graduate from college (Adelman, 1999, 2006; Trusty & Niles, 2003). It has also been suggested that poor preparation in mathematics and science has been shown to affect minorities disproportionately (Gamoran, 2001; Lee, Smith, & Croninger, 1997; Schmidt, 2001; Singham, 2003).

Mathematics and science course sequences contribute to successful college admission in slightly different ways. Mathematics is hierarchical and successful completion of one level is required for successful entry to the next (Reigle-Crumb, 2004-2005; Schneider, 1998; Stevenson, Schiller, & Schneider, 1994). Students who take Algebra I in 8th grade are positioned to take advanced mathematics, such as Calculus I, during senior year. Students who postpone Algebra I past 9th grade lose out on the opportunity to take the higher level courses that are advantageous to college admission. Science course sequences are cumulative. The more rigorous science courses a student takes, the better the student is positioned to be accepted at college. A combination of high level mathematics and science courses is required for college entry (Adelman, 2006). The course sequences that position students in high school are highly predictive of college acceptance and graduation (Adelman, 2006; Reigle-Crumb, 2004-2005; Schneider, 1998; Stevenson, Schiller, & Schneider, 1994).

College selectivity. A number of studies point to college selectivity as an important predictor of future outcomes. Since the demand for slots at selective colleges is greater, competition for the fixed number of slots has increased (Reich, 2000). Students with the highest course sequences are in the best positions to gain access to those slots. Higher college selectivity adds to students' future earning power (Loury & Garman, 1995). Attendance at very selective colleges and universities often lead to lucrative and prestigious careers in medicine, science, and engineering. At the lower end of the selectivity scale are those schools, including community colleges, that are minimally or non-selective. About 80% of the students who opt for these schools have taken the lower course sequences in high school so they are under prepared to begin college level work and may never complete a four year degree (Kirst, 2003; Schneider, 2003). The selectivity of a teacher's college is significantly predictive of increased student achievement (Kennedy, Ahn, & Choi, 2005; Ehrenberg & Brewer, 1994), but, as a rule, teachers do not come from colleges with higher selectivity (Ballou, 1996; Reback, 2002). This leaves the large middle tier of colleges to produce the majority of teachers.

Popular rankings for colleges and universities have been developed by organizations such as US News and World Report, Princeton Review, and Barron's. In spite of differences in survey foci, the American public believes that the ranking systems are synonymous with academic reputation and future earning power. There are differences of opinion in the research community as to what the level of college selectivity accrues to students. Some contend students will do best at schools that match their talents and interests regardless of level of selectivity that the selectivity effect is overrated (Smyth & McArdle, 2004). Some studies which discount the rankings argue that publicity and hype about rankings make the substance of education matter less than the style of the institution (Moll & Wright). Studies of selectivity and teacher effectiveness in mathematics indicate that higher student achievement is related to teachers attending institutions of the highest selectivity (Kennedy, 2005).

Majoring in mathematics or science in college. While the higher level high school mathematics and science course sequences position students to attend colleges of higher selectivity and are prerequisites for majoring in those subjects, not all students decide to major in mathematics or science. Much of the literature on students who major in mathematics and science is centered on economic, demographic, and cultural differences. Mathematics and science related careers are more lucrative than careers in the humanities. Males are more likely than females to enter fields of study with high economic returns (Davies & Guppy, 1997). Mathematics ability and science majors are associated with higher earnings (Arcidiancono, 2004).

Among students initially majoring in science, Blacks are less likely than Whites to graduate in science (Bowen & Bok, 1998); women are less likely to graduate than men although much of the gender effect is related high school course taking (Haines & Wallace, 2002; Turner & Bowen, 1999). One study based on 22 Hispanic students finds that Hispanic students have more success as science and engineering majors than women and other minorities (Brown, 2002). Other studies look at differences in the culture surrounding the subject matter as the reason that students choose a mathematics or science major compared to more literary pursuits (Shuell, 1992)

Teaching mathematics and science. The world of science, mathematics, engineering, medicine, and education are competing for the same pool of highly qualified applicants (Tienda, 2001). Since the introduction of NCLB, the undergraduate requirements for teaching are on par or surpass the requirements for entering other more prestigious and lucrative careers. Since all states missed the highly qualified teacher deadline this year (National Council of Teachers of Mathematics, 2006), problems in the production of mathematics and science teachers is likely a significant contributing factor.

NCLB requires that all teachers hold state certification or licensure, a bachelor's degree or higher and demonstrated knowledge in subjects taught. Demonstrated knowledge includes passing a test of the subject**,** possessing a major, and/or completing state peer review. A student may decide to become a teacher at anytime but without the proper sequences of high school and college mathematics and science courses, meeting the NCLB requirements to become a mathematics or science teacher will be difficult at best.

Special considerations in Texas. As the nation reforms education by requiring high quality mathematics and science teachers for all students under NCLB, educators, policy makers, and stakeholders alike can learn from Texas' example. Texas has two special conditions that made it a particularly important state in which to study high school course sequences in mathematics and science, college acceptance and attendance, majoring in mathematics and science, and the pathway to teaching. Texas required that teachers major in the subject they teach in 1987 ("Senate Bill 994", 1987) so it offers a unique opportunity to study the effects of stricter requirements and accountability on the supply of mathematics and science teachers over time. Additionally, state demographics are in flux. Second only to California in its total Hispanic population, the number of Hispanics in Texas is expected to double by 2025 (U.S. Census Bureau, Population Division). Texas, like other states, is a long way from having its teaching force reflect its population diversity (Kirby, Berends, & Naftel, 1999) although this has been a stated goal of the Texas Board of Education since 1994 (Texas Education Agency, 1994).

If minority admissions to college are hampered by the striking down of affirmative action laws across the country, it will have an effect on the supply of mathematics and science teachers being produced. Texas again may provide valuable lessons. The courts overturned the use of affirmative action in Texas in 1996 ("Hopwood v. Texas", 1996). The Texas Top 10% law, a "race neutral" policy instituted in its stead, guaranteed admission to public universities for all students who are ranked in the top 10% of their graduating class. Research conducted by THEOP investigators indicates that a combination of the Hopwood decision and the Top 10% law is actually making it harder for minorities to enter college (Kain & O'Brien, 2005; Laycock, 2005; Long, July 2005; Tienda, 2001; Tienda & Niu, 2004). One of the legacies of the Top 10% law in Texas is that minority students who take the higher course sequences and do well in them are positioned to attend college but the weight of class rank can work against well-qualified minorities in high minority districts (Kain & O'Brien, 2005; Tienda & Niu, 2004). California and Florida also passed their own versions of the Top 10% law with an eye toward increasing minority attendance but it appears that minority attendance is decreasing in those states as well (Long, July 2005). Similar affirmative action legislation was passed recently by voters in Michigan and a Top 10% bill will soon be introduced. While all states are not currently affected by this trend, it is looming on the American horizon.

SAMPLE.

THEOP collected data on 13,803 high school seniors in 96 Texas high schools in 2002 in Wave I. Minority students were oversampled. Variables included high school indicators (percent of economically disadvantaged students, percent of students in advanced placement courses, dropout rate), student indicators (gender, race/ethnicity, parents' educational attainment, degree aspirations, course sequences), and outcomes for acceptance and attendance at college.

Wave 2 followed up 5,836 students during summer and fall 2003, collecting data on college acceptance, attendance, and majors. Colleges/universities (IHE) were coded on selectivity and augmented with the number of teachers produced by the IHE annually. The full weighted sample (wt n) for Wave 2 represents approximately 210,000 Texas students (48% male, 52% female; 49% White, 10% Black, 33% Hispanic, 4% Asian, 4% other).

Table 1 shows demographic breakdowns for critical points along the pathway to teaching. Table 2 includes the means and standard deviations for the same critical points. Figure 2 illustrates the junctures where students leave the pathway to teaching and their alternative choices. The analyses for this paper focus on those students who remained on the pathway to teaching through 2003.

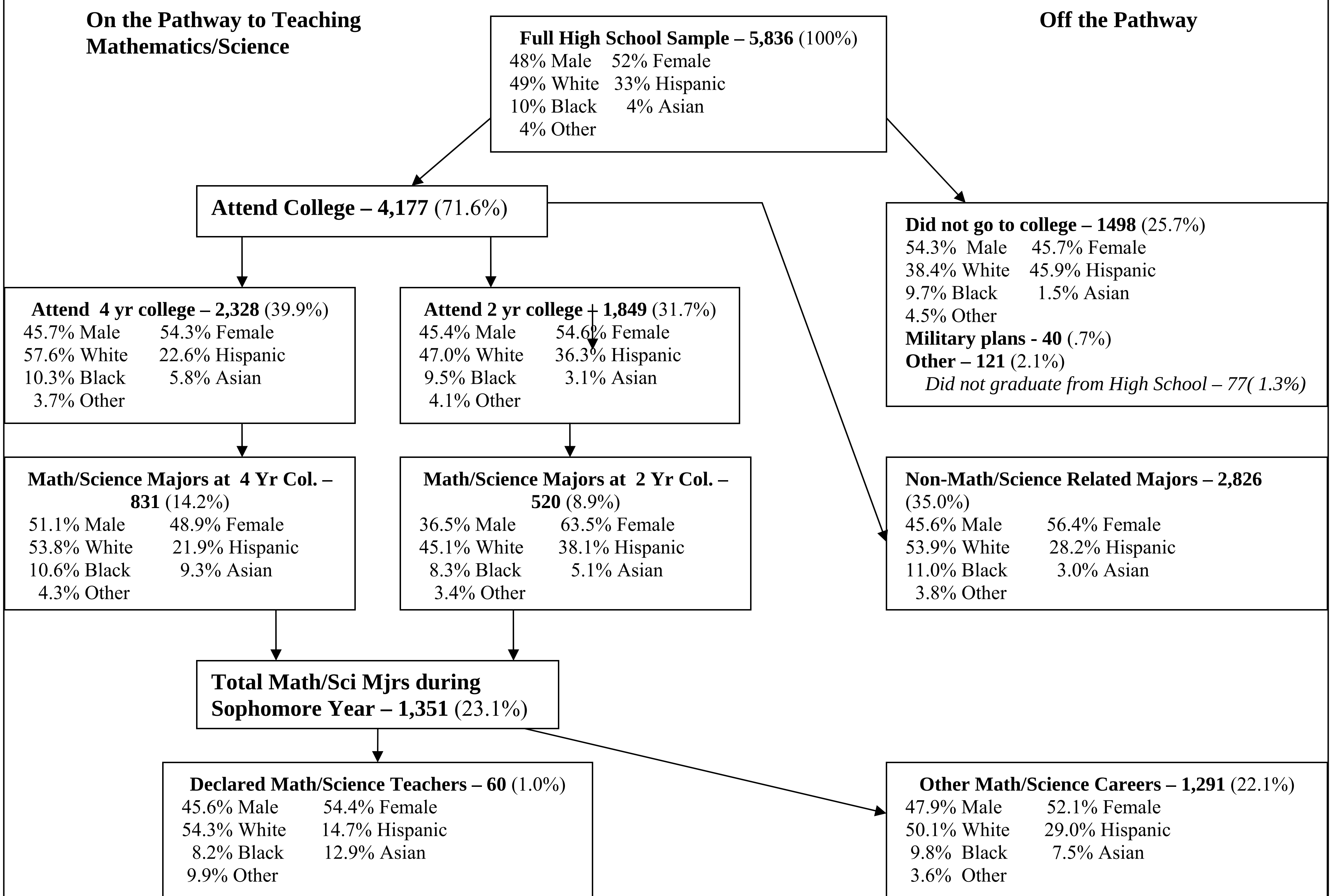
Table 1. Demographic distributions across weighted samples

	1. High School Students	2. Students Who Applied to One or More 4 Yr Colleges	3. Students who Attended 4 Yr Colleges	4. All College Students Majoring in Mathematics /Science	5. All College Students Deciding to Teach Mathematics /Science
N – Original Sample	5836	3312	2328	1351	60
N – Weighted sample	210001	169075	154673	48622	2174
% of Original sample	100%	80.50%	73.70%	23.20%	1.0%
Demographics					
Male	48.0%	41.9%	45.5%	47.0%	45.6%
Female	52.0%	58.1%	54.5%	53.0%	54.4%
White	49.0%	53.9%	57.7%	50.3%	54.3%
Black	9.9%	9.4%	10.2%	9.7%	8.2%
Hispanic	33.2%	28.4%	22.5%	28.4%	14.7%
Asian	3.8%	4.5%	5.9%	7.7%	12.9%
Other (includes missing)	4.0%	3.8%	3.7%	3.9%	9.9%
Math course sequence					
Minimum	9.5%	4.4%	1.3%	4.2%	4.5%
Recommended	41.8%	32.3%	21.2%	25.8%	10.8%
Recommended Plus	47.9%	62.4%	76.4%	68.8%	84.7%
Distinguished	0.8%	0.9%	1.1%	1.1%	0.0%
Science course sequence					
Minimum	11.6%	5.8%	2.1%	3.7%	4.2%
Recommended	32.5%	28.8%	23.0%	24.4%	8.8%
Recommended Plus	54.1%	62.9%	71.3%	68.1%	77.4%
Distinguished	1.8%	2.5%	3.6%	3.8%	9.6%
Expected degree					
High School or less	3.8%	0%	0.5%	0.6%	0.0%
Some college to 2 years	14.3%	6.1%	2.6%	9.5%	0.7%
College graduate (4 years)	33.6%	35.7%	31.8%	26.4%	26.7%
Graduate or professional degree	48.3%	58.2%	66.1%	63.5%	72.6%
Parental Education Level					
High School or less	31.4%	23.5%	15.8%	24.7%	24.1%
Some college to 2 years	26.9%	26.8%	25.5%	26.2%	36.8%
College graduate (4 years)	23.1%	27.3%	30.7%	24.4%	23.7%
Graduate or professional degree	18.6%	22.4%	28.0%	24.6%	15.4%

Table 2. Means (standard deviations) for weighted variables across analysis samples

N – Original Sample		5836	3312	2328	1351	60
N – Weighted sample		210001	169075	154673	48622	2174
% of Original sample		100%	80.5%	73.7%	23.2%	1.0%
Critical Junctures:	Range	**1. High School Course Sequences**	**2. College Acceptance**	**3. College Attendance**	**4. Majoring in Mathematics /Science**	**5. Deciding to Teach Mathematics /Science**
Level 1. Student Characteristics						
Math course sequence	0-3	1.40(1.76)	1.60(3.74)	1.77(1.10)	1.67(1.34)	1.80(1.18)
Science course sequence	0-3	1.46(1.85)	1.62(1.48)	1.76(1.27)	1.72(1.39)	1.91(1.44)
Parental Education	0-8	4.67(4.42)	5.00(4.24)	5.37(4.00)	5.00(4.35)	4.79(3.80)
Desired extent of schooling	0-5	3.42(2.80)	3.79(2.06)	3.95(1.97)	3.87(2.33)	4.22(1.95)
Highest selectivity accepted	1-5	-	3.39(1.75)	3.49(1.69)	3.46(1.75)	3.71(1.40)
Highest selectivity attended	1-5	-	-	3.08(1.85)	3.14(1.88)	3.58(1.49)
Level 2. High School Characteristics		n=90	n=90	n=90	n=55	n=55
% Economic disadvantage		34.91(25.38)	34.91(25.38)	34.91(25.38)	-	-
% Taking AP courses		12.25(49.28)	12.25(49.28)	12.25(49.28)	-	-
Total dropout rate	0-5	1.47(2.84)	1.47(2.84)	1.47(2.84)	-	-
Level 2. College Characteristics						
Teacher production intensity	13-860	-	-	-	201.98(199.93)	201.98(199.93)
US News rank	1-5	-	-	-	2.85(.85)	2.85(.85)

Figure 2. Demographic shifts along the pathway to teaching



VARIABLES (see Tables 1 and 2)

Three sets of variables are used in the analysis: student variables, high school variables and college variables. Level 1 student level variables include gender and race/ethnicity (coded 1 or 0), scales for course sequences, parental education, desired extent of schooling (student aspirations), and highest selectivity of college of acceptance and attendance. Once in college, student level variables also include whether or not students are planning mathematics majors and whether or not they intend to teach (coded as 1 or 0). Level 2 high school level variables include percent economically disadvantaged students (free and reduced lunch). Level 2 university level variables include selectivity level from US News and World Report rankings and teacher production intensity (the number of teachers produced by Texas universities reported by Texas Education Agency in 2002). A description of the construction of the scales for mathematics and science course sequences follows.

Course sequences. While it is difficult to guarantee that course academic content is consistent across teachers and schools, Texas has a very strong, centralized curriculum with state monitoring of the curriculum in place. We used the 2002 Texas course graduation recommendations to develop the sequence levels matched to the context of Texas.

In the Wave I survey, THEOP students reported the mathematics and science courses they had taken, or were presently taking, including Algebra I, Geometry, Algebra II, Pre-Calculus, Calculus, or any advance placement (AP) mathematics courses. Students were also asked if they had taken or were taking Biology, Physics, Chemistry, or any AP science courses. If AP courses were attempted, the examination pass level was included in the course sequence designation.

The *minimum level* of mathematics sequence included students who had taken at least Algebra I and Geometry. For the *recommended level* of mathematics sequence, students had completed Algebra II as well as Algebra I and Geometry. The *recommended plus level* included students who had taken at least Precalculus plus the required prior mathematics courses. The *distinguished level of mathematics* included students who had taken at least Algebra II or higher mathematics courses such as Pre-Calculus and Calculus as well as AP mathematics with a score higher than 3.0.

The *minimum level* of science sequence included students who had taken only one science subject. For the *recommended level* of science sequence, students had taken at least two of the three science subjects. For the *recommended plus level* of science sequence, students had taken at least two of the three science subjects and an AP science course, but the grade on AP science was not higher than 3.0. The *distinguished level for science* included students who had taken at least two of three laboratory science courses – Biology, Physics, Chemistry, and AP science with score higher than 3.0.

METHODS

There are five critical junctures along the pathway to teaching represented in this data. They are:

1. Completing high school mathematics and science sequences
2. Applying to and being accepted at a college or university
3. Attending a college or university
4. Majoring in mathematics and/or science
5. Deciding to teach mathematics and/or science

The study first analyzed demographic distributions at each of these time points followed by multilevel logistic regression with students nested within high schools. In order to determine the probability of majoring in mathematics or science or becoming a teacher of those subjects, students were nested within universities. Standard errors were adjusted for design effects and sampling weights corrected for student and school level non-response.

After the discussion of the demographic patterns, we present the HLM results that predict who takes what levels of mathematics and science sequences by race/ethnicity and gender based on desired extent of schooling and parental education controlling for high school economic disadvantage. Next, we note the results as high school course sequences predict college acceptance and attendance by race/ethnicity and gender. Once students are attending college, we present the results of the analysis where high school course sequences predict majoring in mathematics or science by race/ethnicity and gender followed by the analysis where high school course sequences predict becoming mathematics or science teachers by race/ethnicity and gender.

STUDY LIMITATIONS

There are two study limitations that need to be mentioned. First, all student data is self-report. Several questions appeared in both Wave 1and Wave 2 data collections and were cross-checked. Other responses were given at only one time point. While there is no reason to believe that students answered questions incorrectly, the possibility exists.

The second limitation is that Wave 2 data ends during the sophomore year in college. There are many opportunities for students to jump on and off the pathway to majoring in mathematics and science as well as teaching those subjects later in their college careers. Consequently, Wave 2 data may misreport both outcomes.

DETERMINANTS OF HIGH SCHOOL COURSE SEQUENCE LEVELS

It is important to recognize that the course sequences a student undertakes in high school and his/her desired extent of schooling are at least partially under the control of the student and therefore point to potential intervention points. Parental education level and high school economic disadvantage are not under student control, therefore we control for them in the analysis.

While it is interesting to look at the total number of students in each ethnic/racial category, this only tells us what we already know about the distribution of the student population in Texas. It is more informative to look at the within gender and within race/ ethnicity percentage for each course sequence variable. This allows us to compare students using the same metric across racial/ethnic/gender categories.

Mathematics and Science Course Sequences

Tables 3 and 4 show the within gender/race/ethnicity percentages for mathematics and science course sequences. Each table is followed by a discussion of the distribution. Since we are cross tabulating categorical variables with a variable that can be conceived of as either categorical or ordinal, we include both χ^2 and η to test for significance.

Table 3. Distribution of Mathematics Course Sequences within Gender & Ethnicity

	Male	Female	White	Black	Hispanic	Asian	Other
Minimum	11.0%	8.2%	8.0%	16.6%	9.8%	2.9%	15.1%
Recommended	41.5%	42%	35.8%	47.6%	51.8%	15.6%	41.5%
Recommended Plus	46.2%	49.4%	55.7%	35.2%	37.7%	75.4%	42.4%
Distinguished	1.3%	.4%	0.5%	0.6%	0.7%	6.1%	1.1%
Total	100%	100%	100.0%	100.0%	100.0%	100.0%	100.0%
	χ^2 = 26.23, p<.000 η = .032		χ^2 = 359.84, p<.000 η = .210				

Males and females take very similar mathematics course sequences. Black and Hispanic students generally take lower level course sequences in mathematics and Asian students tend to take higher level course sequences than other groups. Overall, the majority of all students take either the Recommended or Recommended Plus mathematics course sequences.

Table 4. Distribution Science Course Sequences within Gender & Ethnicity

	Male	Female	White	Black	Hispanic	Asian	Other
Minimum	13.1%	10.2%	11.7%	16.2%	10.5%	5.3%	14.2%
Recommended	30.7%	34.2%	30.5%	37.7%	36.2%	18.0%	26.6%
Recommended Plus	53.7%	54.4%	55.9%	45.2%	52.1%	68.3%	57.0%
Distinguished	2.5%	1.3%	1.9%	0.9%	1.2%	8.3%	2.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	χ^2 =26.68, p< .000 η = .008		χ^2 =127.49, p< .000 η = .117				

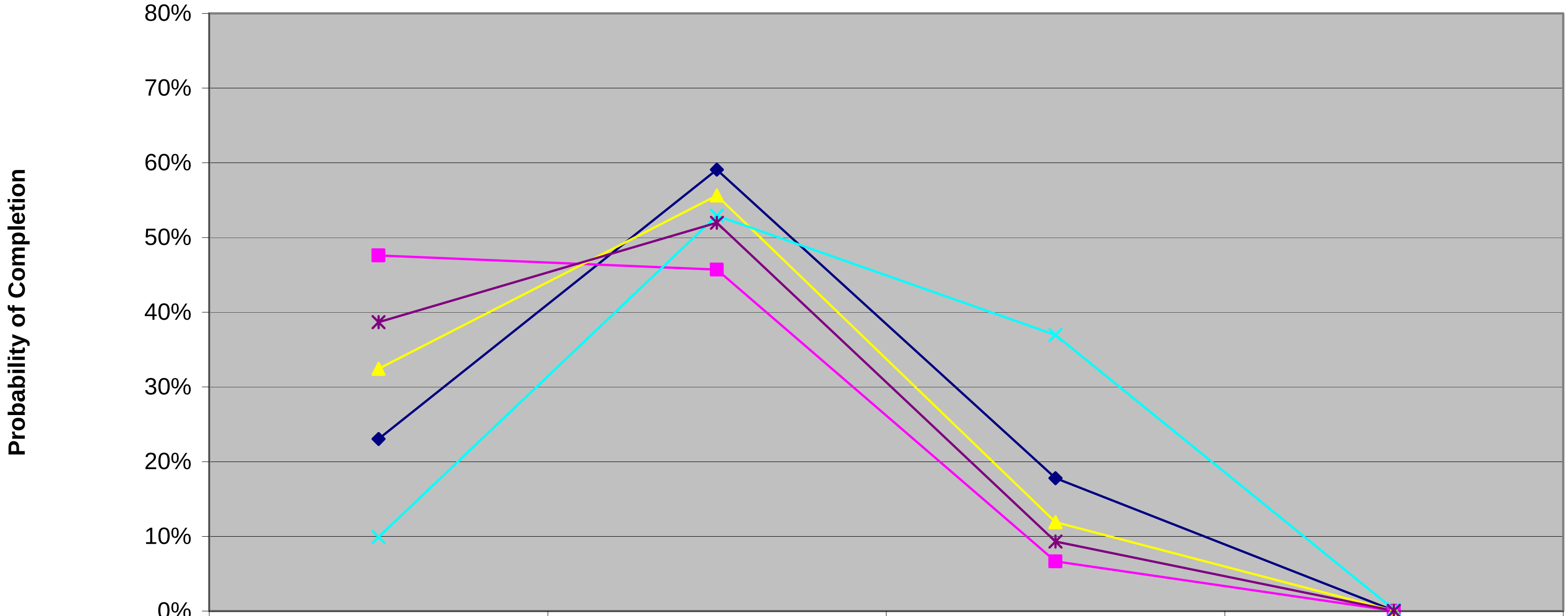
As in mathematics, males and females take similar science course sequences. Black students generally take lower levels of science course sequences than other groups. Again, Asian students take Recommended Plus and Distinguished course sequences at a greater rate than their classmates. Note that majority of students in all demographic groups took the Recommended Plus science course sequence level.

The demographic distribution of course sequences is not “new” news in Texas. It only underlies what we know already about the distribution of equality of access to education in the United States. More important is to discover the predictors of this distribution so that we might determine the factors that are under student or high school control with the potential to be manipulated to improve outcomes for all students. Improving high school course sequence equality will lead to more science and mathematics majors in college and subsequently more highly qualified teacher candidates at the college level.

Mathematics course sequences. The following two level hierarchical ordinal regressions predict mathematics course sequence by gender and race/ethnicity controlling for the background factors that students can change - student degree expectations - and those they cannot change – parental education level and high school economic disadvantage. HLM listwise deletes cases that are missing on the variables included in the specific analysis. Project investigators decided not to impute missing due to the large sample size and low incidence of missing on individual variables.

Reliability for each model exceeds 75%. Results can be interpreted as the probability of being in a particular mathematics course sequence or the log odds of completing one of four mathematics course sequences (minimum to distinguished) predicted by student demographic group controlling for mean parental education level, degree aspirations, and high school economic disadvantage. Student coefficients for Black, Hispanic and Asian were significantly different from zero. Figure 3 shows the results of the analysis by in terms of predicted probabilities followed by an interpretation of log odds for students.

Figure 3. Probability of Completing a Mathematics Course Sequence By Race/Ethnicity Controlling for Mean Parental Education, Student Degree Aspirations, and High School Economic Disadvantage (see Appendix Table 1 for coefficients)



	1 - Minimum	2 - Recommended	3 - Recommended +	4 - Distinguished
White	23.04%	59.10%	17.78%	0.08%
Black***	47.62%	45.70%	6.65%	0.03%
Hispanic*	32.42%	55.63%	11.90%	0.05%
Asian*	9.91%	52.92%	36.94%	0.22%
Other	38.66%	51.98%	9.32%	0.04%

Mathematics Sequence Level

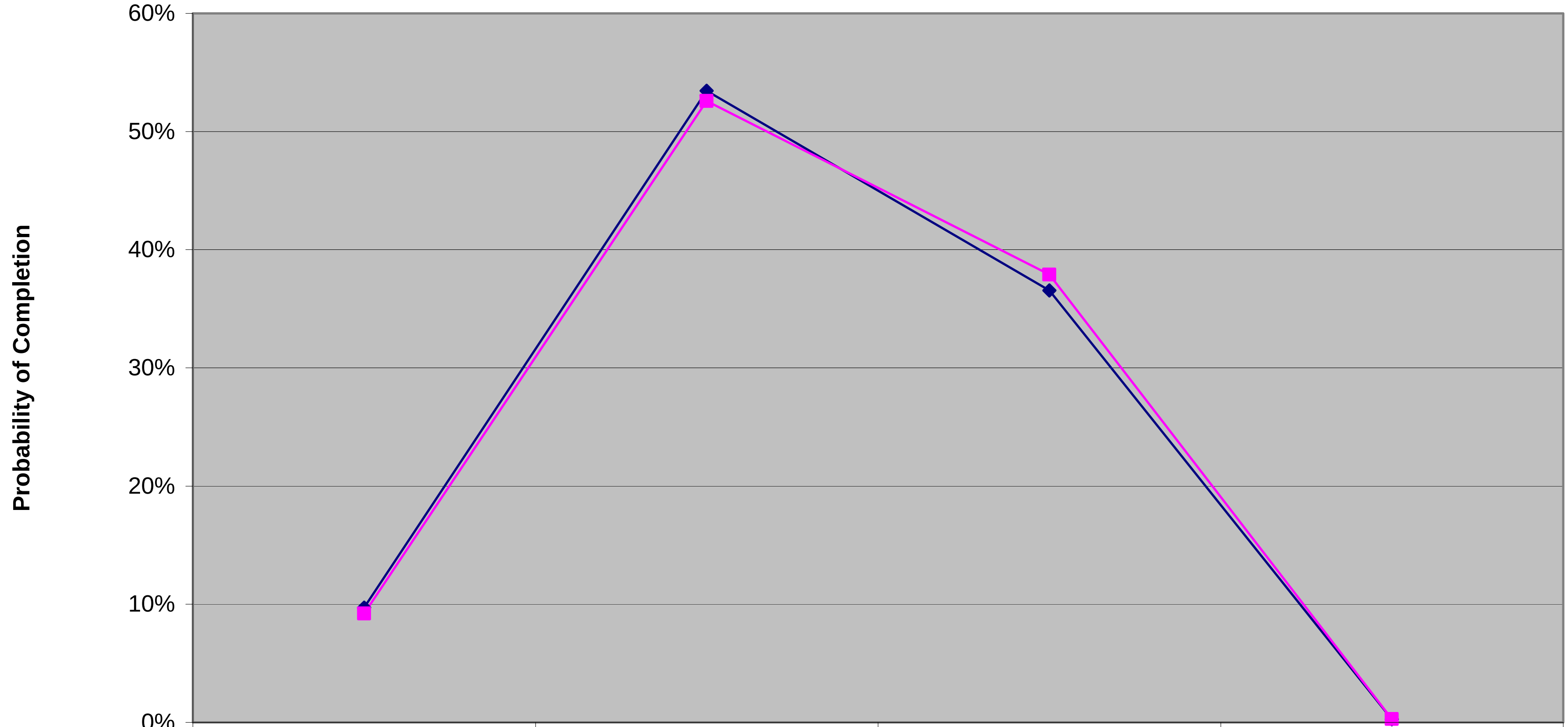
In the analysis, Black students are 3 times more likely and Hispanic students are 1.6 times more likely than White students to complete the minimum mathematics course sequence in high school controlling for parental education level, degree aspirations, and high school economic disadvantage. White students are 2.7 times as likely to be in the minimum course sequence when compared to Asian students. White students are 1.2 to 1.7 times more likely to fall in the recommended sequence than all other groups.

White students are 3 times more likely to be in recommended plus level compared to Black students and 1.6 times more likely than Hispanic students. Asian students are 2.7 times as likely as Whites to be in the recommended plus category. When it comes to taking the distinguished course sequence, Asians are more likely to complete this level than all other students.

In sum, Asians are more likely than Whites to be in the highest mathematics course sequences levels and Whites more likely to be in the moderate to high course sequences with the majority of Hispanic and Black students more likely to take the lower to moderate course sequences controlling for parental education level, degree aspirations, and high school economic disadvantage.

As Table 4 illustrates, there are no gender difference between males and females when it comes to taking mathematics course sequences controlling for parental education level, degree aspirations, and high school economic disadvantage.

Figure 4. Probability of Completing a Mathematics Course Sequence By Gender Controlling for Mean Parental Education, Student Degree Aspirations, and High School Economic Disadvantage (see Appendix Table 2 for coefficients)



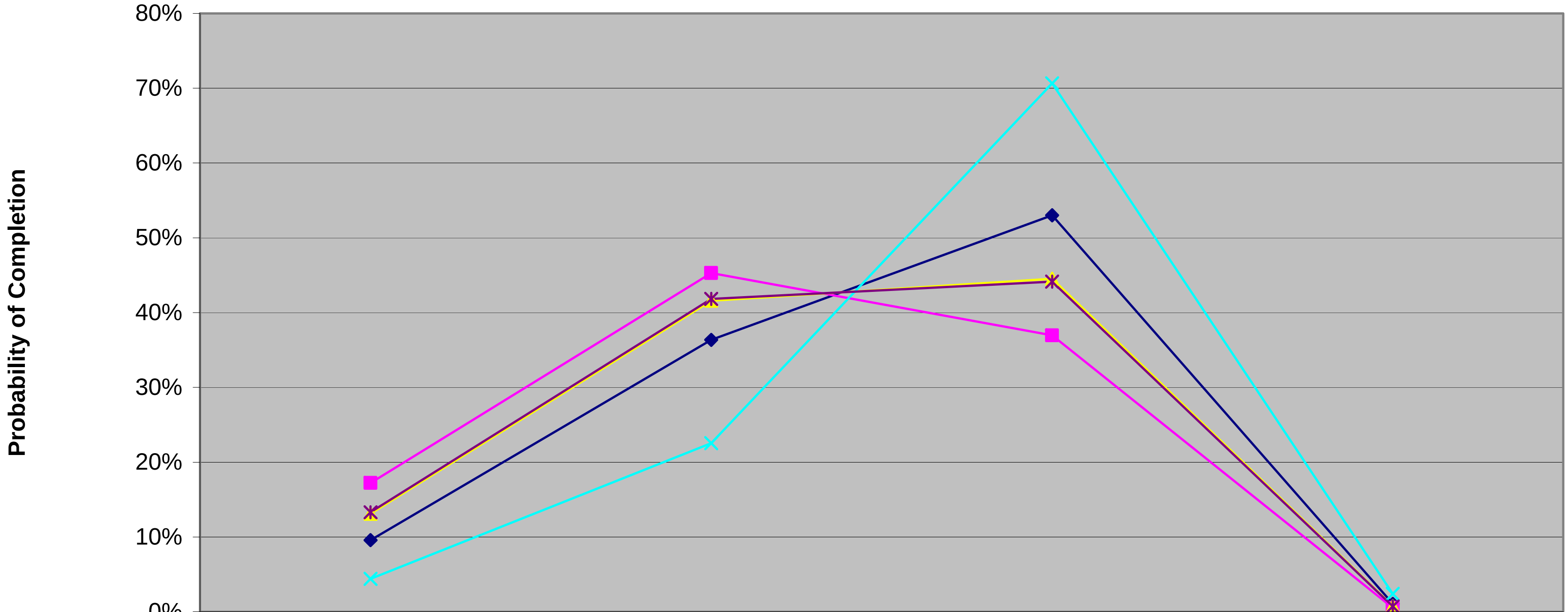
	1 - Minimum	2 - Recommended	3 - Recommended +	4 - Distinguished
Male	9.72%	53.46%	36.55%	0.27%
Female	9.23%	52.59%	37.89%	0.29%

Sequence level

Raising a student's degree aspirations increases the odds of taking a higher mathematics course sequence. A one unit change in degree aspirations is related to a .5 increase in mathematics course sequence. This means if a student shifts his or her sights from graduating from high school to graduating from college – a two unit change - it significantly increases the odds of completing the next highest mathematics course sequence.

Science course sequence. Figure 4 presents the results for science course sequences by race/ethnicity. While the majority of students are located in the Recommended level, more students opt to take Recommended Plus in science than in mathematics. Results by gender vary from the mathematics results and are presented in Figure 5. Reliability for the models exceeds 99% again due to the large number of students within high schools.

Figure 5. Probability of Completing a Science Course Sequence By Race/Ethnicity Controlling for Mean Parental Education, Student Degree Aspirations, and High School Economic Disadvantage (see Appendix Table 3 for coefficients)



	1 - Minimum	2 - Recommended	3 - Recommended +	4 - Distinguished
White	9.59%	36.34%	53.01%	1.06%
Black*	17.24%	45.28%	36.94%	0.54%
Hispanic	13.11%	41.60%	44.54%	0.75%
Asian*	4.41%	22.55%	70.64%	2.40%
Other	13.31%	41.83%	44.14%	0.73%

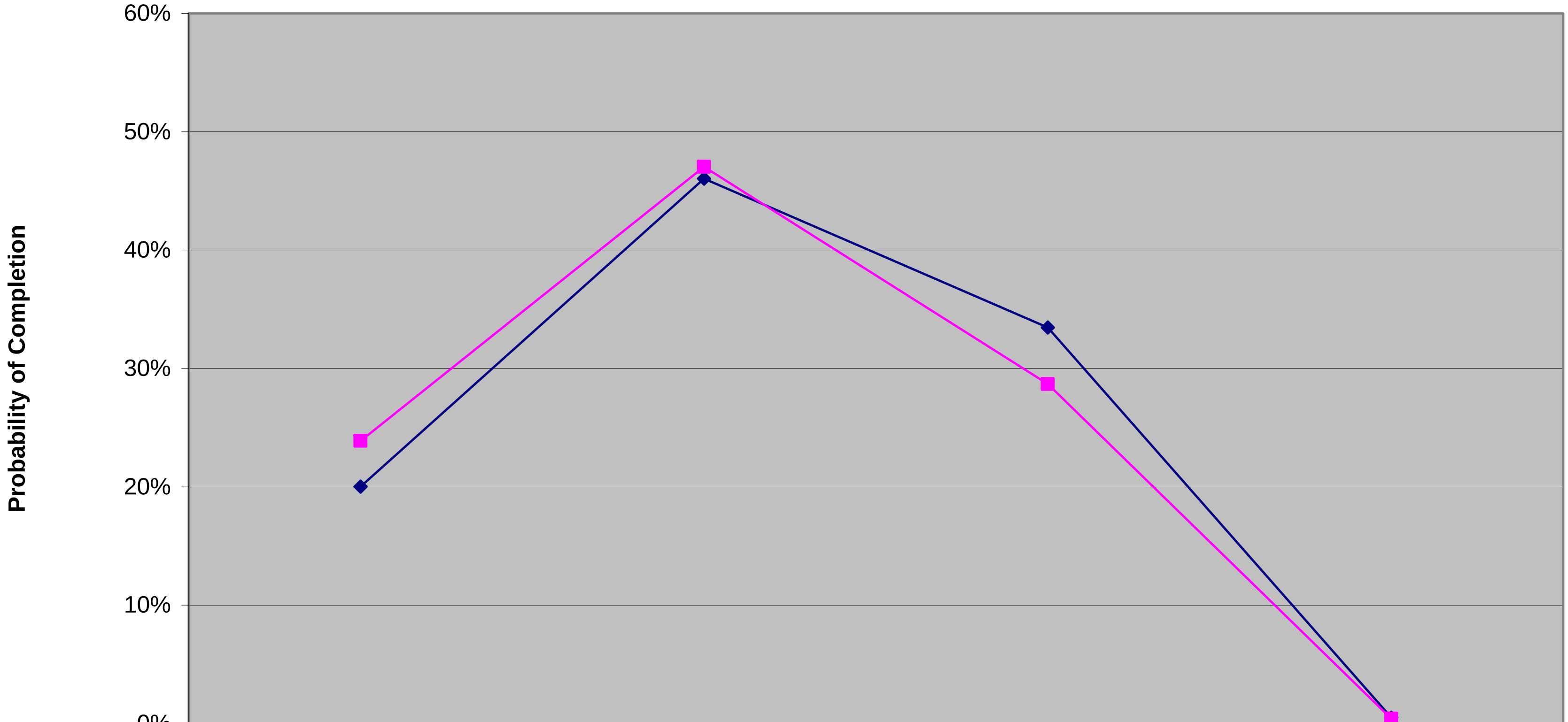
Science Course Sequence Level

Trends are similar to mathematics although students are more likely to take higher course sequences in science than in mathematics. The analysis controlled for parental education level, degree aspirations, and high school economic disadvantage. Black students are 2 times more likely and Hispanic students 1.4 times more likely to complete the minimum science course sequence as compared to White students. White students are 2.3 times more likely to be in the minimum course sequence compared to Asian students.

Black students are more likely (1.4 times) to be in the recommended course sequence compared to White students and Hispanic students are 1.2 times as likely. The odds for White students to be in the Recommended Plus or Distinguished science course sequence increase to 1.4 to 2.0 times as likely as other students with the exception of Asian students who are 2.3 times as likely as White students to be in the recommended plus or distinguished categories.

In general, Asian students are more likely than White students to be in the highest course sequences levels, White students more likely to be in the moderate to high science course sequences, and Hispanic and Black students more likely to complete lower to moderate course sequences controlling for parental education level, degree aspirations, and high school economic disadvantage. A two unit change in degree aspirations increases the level of science course sequence completed by one level for all students.

Figure 6. Probability of Completing a Science Course Sequence By Gender Controlling for Mean Parental Education, Student Aspirations, and High School Economic Disadvantage (see Appendix Table 4 for coefficients)



	1 - Minimum	2 - Recommended	3 - Recommended +	4 - Distinguished
Male	20.01%	46.04%	33.45%	0.50%
Female	23.88%	47.05%	28.67%	0.40%

Science Course Sequence

As Table 6 illustrates, there are no gender difference between males and females when it comes to taking science course sequences controlling for parental education level, degree aspirations, and high school economic disadvantage.

DETERMINANTS OF ACCEPTANCE AND ATTENDANCE BY COLLEGE SELECTIVITY LEVEL

The next step in the analysis looked at mathematics and science course sequences and their relationships to the selectivity level of college acceptance and attendance at 4 year colleges, parental education level, degree aspirations, and high school economic disadvantage. We have already seen that students are stratified by the mathematics and science course sequences that they take. This stratification is strongly related to degree aspirations which can be controlled by the student and parental education which cannot. These variables also related to race/ethnicity and gender.

In this data, 60.8% of White students and 69.9% of Asian students went to four-year colleges, but only 44.0% of Hispanic students went to four-year colleges. Among students who went to four-year colleges, more White and Asian students went to ‘more’ or ‘most’ selective colleges compared to their Hispanic and Black peers. While 44.3% of White students and 65.6% of Asian students went to “more” or “most” selective colleges, only 18.3% of Hispanic students and 15.9% of Black students went to four year colleges of the same level. The simple distribution of college-going students alone does not tell the whole story.

As Table 5 reveals, students in this data are also stratified by the types of college they choose to attend. White, Black, and especially Asian students tend to choose four-year colleges while Hispanic students tend to choose two-year colleges. The analyses following Table 5 focus on four year college rankings only.

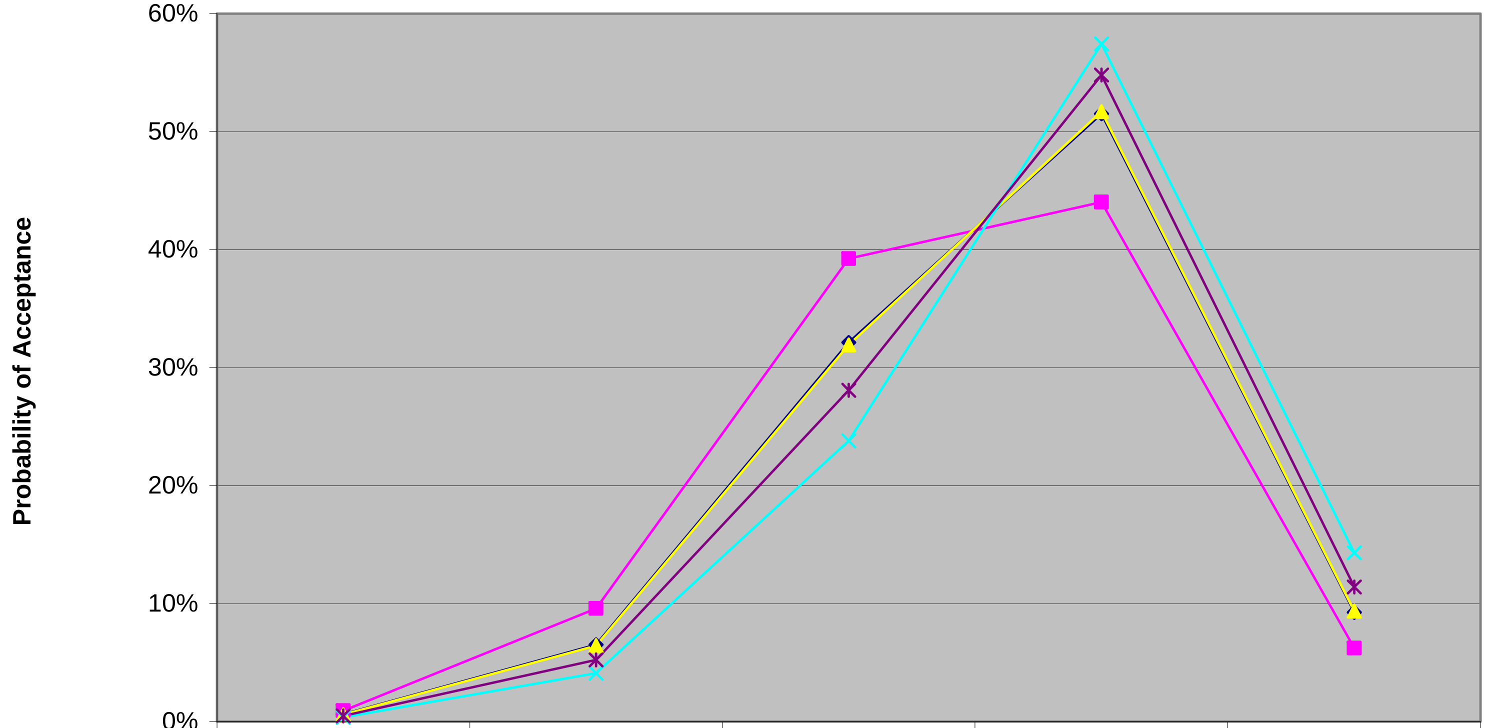
Table 5. Distribution of College Type by Gender and Ethnicity

	Male	Female	White	Black	Hispanic	Asian	Other
4 year College	38.50%	42.30%	47.50%	42.10%	27.50%	62.80%	37.00%
2 Year College	29.90%	33.30%	30.30%	30.40%	34.60%	26.60%	32.30%
Other School	31.60%	24.40%	22.20%	27.50%	37.90%	10.60%	30.70%
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	χ^2 = 36.97, p<.001		χ^2 = 309.30, p<.001				

College Acceptance

When the selectivity level of the college of acceptance is predicted by race ethnicity and the factors that students can alter (course sequences in mathematics and science and degree aspirations) controlling for parental education, and high school SES, the following picture emerges. Note that students who attend community colleges are not included in the selectivity analyses since US News and World Report only ranks 4 year institutions.

Figure 7. Acceptance by College Selectivity and Race/Ethnicity Predicted by Mathematics/ Science Course Sequences Controlling for Mean Parental Education, Student Degree Aspirations, and High School Economic Disadvantage (see Appendix Table 5)



	Least Selective	Less Selective	Selective	More Selective	Most Selective
White**	0.60%	6.51%	32.13%	51.51%	9.25%
Black~	0.92%	9.58%	39.24%	44.02%	6.24%
Hispanic	0.60%	6.44%	31.92%	51.70%	9.35%
Asian	0.37%	4.09%	23.80%	57.42%	14.32%
Other	0.48%	5.23%	28.09%	54.78%	11.42%

Selectivity Level (US NEWS)

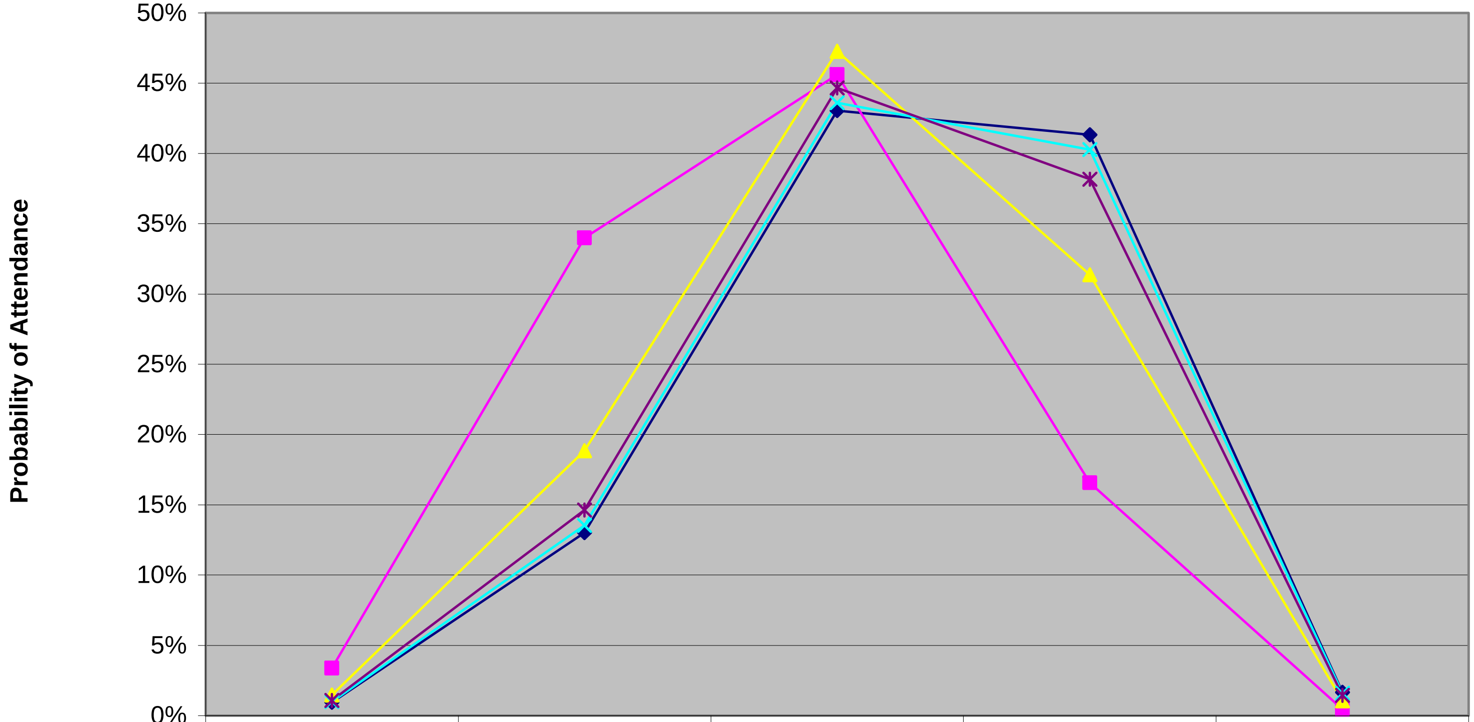
Mathematics and science course sequences do not predict the selectivity level of college acceptance although they are predictive of college acceptance in general. There were no gender differences in selectivity of college acceptance. Students with higher degree aspirations were significantly more likely to be accepted at more selective colleges. To compare the likelihood of college acceptance by race/ethnicity, odds ratios were computed within four college selectivity categories (least selective, less selective, selective, and more selective). The sample in most selective colleges is quite small and consequently biased so this category is not discussed.

After controlling for mean values of anticipated degree, parental education, mathematics course sequence, science course sequence, and high school economic disadvantage, Black students were more likely than White students to be accepted at the least selective (1.5), less selective (1.5), and selective colleges (1.3). They were less likely to be accepted in more selective colleges than White students (1.4). In other words, Black students were more likely to be accepted into less selective four year colleges than White students, controlling for course sequencing and demographic variables. The differences between Black and White students were statistically significant but the very small differences between Hispanic, Asian, and Other students were not statistically significant.

College Attendance

The picture changes in some interesting ways when the selectivity level of the college of attendance is predicted by the same equation. Note that students who attend community colleges are not included in the selectivity analyses since US News and World Report only ranks 4 year institutions.

Figure 8. Attendance by College Selectivity and Race/Ethnicity Predicted by Mathematics/ Science Course Sequences Controlling for Mean Parental Education, Student Degree Aspirations, and High School Economic Disadvantage (see Appendix Table 6)



	Least Selective	Less Selective	Selective	More Selective	Most Selective
White	0.94%	13.02%	43.06%	41.32%	1.66%
Black**	3.38%	33.98%	45.62%	16.56%	0.46%
Hispanic	1.47%	18.84%	47.26%	31.36%	1.06%
Asian	0.99%	13.53%	43.61%	40.28%	1.58%
Other	1.08%	14.64%	44.67%	38.17%	1.44%

Selectivity Level (US NEWS)

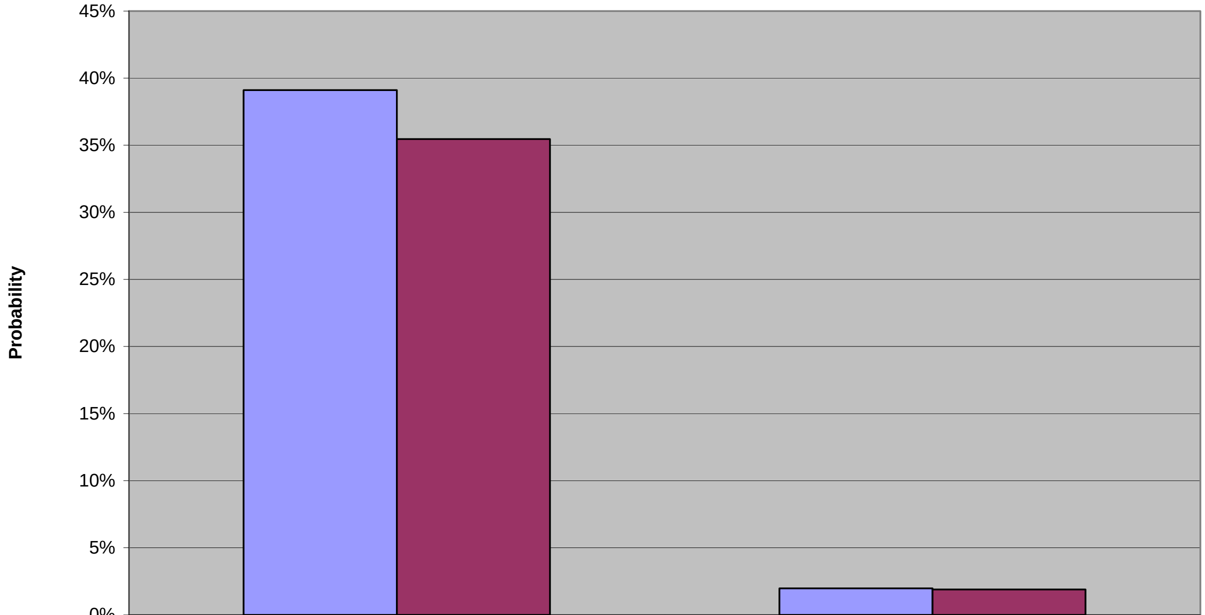
Both mathematics and science course sequences in high school predict college selectivity level: as students completed higher course sequences, they were more likely to attend more selective colleges. Students with higher anticipated degrees were more likely to attend more selective colleges. There were no gender differences in selectivity of college attendance. Just as in the results for acceptance, parental education level was no longer predictive of selectivity level for the college of attendance.

Odds ratios comparisons are reported for four college attendance selectivity categories (least selective, less selective, selective, and more selective). Controlling for the mean values of anticipated degree, parental educational, mathematics course sequence, science course sequence, and high school economic disadvantage, only Black students had significant differences in selectivity for college of attendance compared to White students. Black students were 3.7 and 3.4 times more likely to attend least selective and less selective colleges respectively than White students, and White students were 3.5 times more likely to attend more selective colleges than Black students. Differences for both Asian and Hispanic students when compared to White students were not statistically significant. All students generally attend colleges of lower selectivity than the highest ones which accepted them.

DETERMINANTS OF COLLEGE MATHEMATICS/SCIENCE MAJOR AND TEACHING MATHEMATICS OR SCIENCE

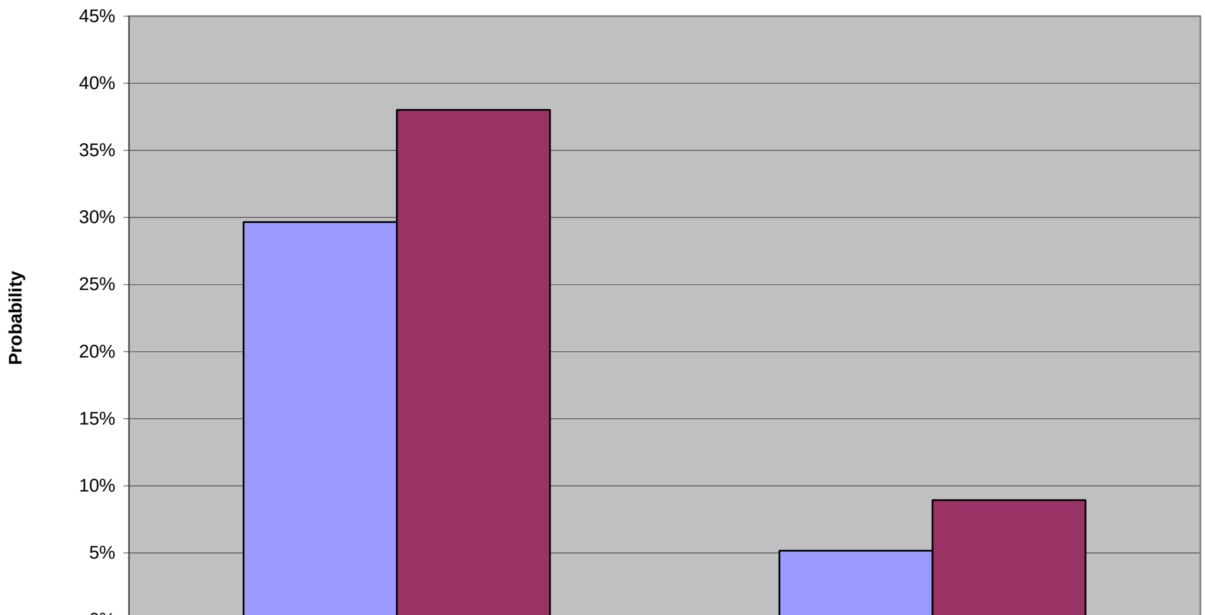
Until students opt to leave college prior to graduation, they are still potentially on the pathway to majoring in mathematics or science and possibly teaching those subjects. All students attending college, including those at two-year institutions, were included in the first logistic regression results. In the second set of results from the two level logistic regressions, students were nested within four-year colleges. Mathematics and science course sequences as well as degree aspirations are generally predictive of majoring in mathematics and science; however, as students choose majors, race/ethnicity is no longer a significant factor in predicting mathematics and science majors or becoming mathematics/science teachers. Gender predicts the probability of becoming mathematics/science majors and teachers. Parental education is no longer significant as a predictor once students attend college so it was dropped from the college level analyses. Figures 9 and 10 illustrate the probability of mathematics and science major and mathematics and science teaching by gender.

Figure 9. Probability of Mathmatics/Science Major & Teacher by Gender Controlling for Course Sequences and Student Aspirations for All College-Attending Students (see Appendix Tables 7 & 8 for Coefficients)



	Mathematics/Science Major	Mathematics/Science Teacher
Male***	39.10%	1.97%
Female*	35.46%	1.88%

Figure 10. Probability of Mathmatics/Science Major & Teacher by Gender Controlling for Course Sequences and Student Aspirations for Students in Four-Year Institutions (see Appendix Tables 9 & 10 for Coefficients)



	Mathematics/Science Major	Mathematics/Science Teacher
Male***	29.65%	5.16%
Female*	38.01%	8.94%

In Figure 9, differences between male and female mathematics/science majors and those planning to teach mathematics or science are not statistically different from zero. In contrast, Figure 10 shows results for the subsample of students who attend four-year institutions. Females are 1.5 times as likely to major in mathematics and 1.8 times as likely to teach mathematics and science compared to males although they have identical educational aspirations and high school course sequences. Four-year universities do not vary significantly across gender when predicting the probability of majoring in mathematics and science but they do vary significantly (τ_{00} =.475, $p<.001$) across gender when predicting the probability of becoming mathematics and science teachers. The variation is not explained by university selectivity or teacher production intensity (number of teacher produced).

DISCUSSION

There are indications that race is related to inequality at various points along the pathway to attending colleges and the selectivity of those colleges. Differences in college acceptance and attendance selectivity among racial/ethnic groups are not sufficiently explained by background factors such as parental education level or high school economic disadvantage.

In the high school level analyses, the course sequences that students take in mathematics and science predict college acceptance and attendance; however, course sequences are highly stratified by race/ethnicity. Black and Hispanic students clearly take lower course sequences than their White or Asian peers. As suggested by Schneider (1998), students with more rigorous course sequences are more likely to attend college. White and Asian student predominate the higher course sequences in this data and attend college at higher within category percentages.

Black students are also disproportionally affected in the selectivity of college acceptance and attendance although they have the same course sequences levels as their classmates, not lower ones as suggested by prior studies (Gamoran, 2001; Lee, Smith, & Croninger, 1997; Schmidt, 2001; Singham, 2003).

Once students enter college, race/ethnicity is no longer a significant factor in the decision to major in mathematics or science. High school mathematics and science course sequences and degree aspirations continue to predict majors but gender becomes the salient factor in predicting the probability of majoring in mathematics and science. The literature points to men outnumbering women in mathematics and science majors (Haines & Wallace, 2002; Turner & Bowen, 1999). Unlike those studies, we found no difference in major by gender at the sophomore year for the combined two- and four-year college-attending students. When looking at students attending four-year institutions, women had a higher probability than men of majoring in mathematics or science as well as teaching those subjects. Two possible explanations for large number of women majors may be related to the rigorous high school graduation requirements in Texas in 2002 or related to the timing of data collection during sophomore year. Many universities do not require students to declare majors officially until junior year and many students continue to change their minds after that. Perhaps only highly motivated women were declared at the time of data collection. Wave 3 THEOP data may provide further insight as students are interviewed during senior year.

In general, degree aspirations are a powerful predictor of mathematics and science course sequence levels in high school. The higher the degree aspirations, the higher the course sequences. Higher course sequences predict college acceptance and attendance and higher science course sequences are related to higher selectivity in college of attendance. Most importantly, the combination of high degree aspirations and high course sequences in high school has a strong positive relationship to college acceptance, attendance, and majoring in mathematics and science controlling for the negative effects of low parental education and high school economic disadvantage. This finding may point the way to potential interventions to improve student mathematics and science outcomes and consequently the quality of aspiring teachers on the pathway to teaching.

Even so, increasing the number and diversity of highly qualified mathematics and science teachers may continue to be difficult since this analysis underscores that prestigious and more lucrative careers than teaching appear to be attracting a large portion of the highly qualified candidates. Only 60 students out of a potential 5,836 remained on the pathway to teaching at sophomore year. In order to ensure a highly qualified, representative teaching force, the government and the education system alike may have to consider upgrading the status of teaching. This could include providing more competitive salaries, benefits, and career ladders for all teachers in order to recruit and retain highly qualified mathematics and science majors to teaching. Unfortunately as of 2009, the national economic crisis renders potential solutions such as these unlikely for the foreseeable future.

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Appendix

Table 1. (Figure 3)

Fixed Effects	*Coefficient*
Outcome: *Mathematics course sequence by Race/Ethnicity*	
Intercept:, γ_{00}	-0.672
Economic, γ_{01}	-0.002
Black, γ_{10}	1.111***
Hispanic, γ_{20}	0.472*
Asian, γ_{30}	-1.000*
Other, γ_{40}	0.745
Expected Degree, γ_{50}	-0.509***
Parent Education, γ_{60}	-0.174**
Threshold Difference, δ_2	2.732***
Threshold Difference, δ_3	8.318***
Random Effect	*Variance Component*
u_{0j}	0.635***

†$p < .1$, *$p < .05$, **$p < .01$, ***p<.001

Table 2. (Figure 4)

Fixed Effects	*Coefficient*
Outcome: *Mathematics course sequence by Gender*	
Intercept:, γ_{00}	-0.320
Economic, γ_{01}	0.005
Female, γ_{10}	0.058
Expected Degree, γ_{20}	-0.510^{***}
Parent Education, γ_{30}	-0.071^{**}
Threshold Difference, δ_2	2.672^{***}
Threshold Difference, δ_3	8.116^{***}
Random Effect	*Variance Component*
U_{0j}	0.645^{***}

$^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$, ***p<.001

Table 3. (Figure 5)

Fixed Effects	*Coefficient*
Outcome: *Science course sequence by Race/Ethnicity*	
Intercept:, γ_{00}	-0.676
Economic, γ_{01}	-0.006
Black, γ_{10}	0.675*
Hispanic, γ_{20}	0.352
Asian, γ_{30}	-0.834*
Other, γ_{40}	0.369
Expected Degree, γ_{50}	-0.438***
Parent Education, γ_{60}	-0.124*
Threshold Difference, δ_2	2.080***
Threshold Difference, δ_3	6.786***
Random Effect	*Variance Component*
u_{0j}	0.778***

†$p < .1$, *$p < .05$, **$p < .01$, ***p<.001

Table 4. (Figure 6)

Fixed Effects	*Coefficient*
Outcome: *Science course sequence by Gender*	
Intercept:, γ_{00}	-0.513
Economic, γ_{01}	-0.001
Female, γ_{10}	0.258
Expected Degree, γ_{20}	-0.460***
Parent Education, γ_{30}	-0.134*
Threshold Difference, δ_2	2.059***
Threshold Difference, δ_3	6.712***
Random Effect	*Variance Component*
U_{0j}	0.784***

$^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$, ***p<.001

Table 5. (Figure 7)

Fixed Effects	*Coefficient*
Outcome: *College Acceptance Selectivity (MAXUSST)*	
Intercept:, γ_{00}	-2.381**
Economic, γ_{01}	0.015
Black, γ_{10}	0.427†
Hispanic, γ_{20}	-0.012
Asian, γ_{30}	-0.495
Other, γ_{40}	-0.235
Expected Degree, γ_{50}	0.444*
Mathematics Sequence, γ_{60}	-0.212
Science Sequence, γ_{70}	-0.346
Parent Education, γ_{80}	-0.078
Threshold Difference, δ_2	2.822***
Threshold Difference, δ_3	4.979***
Threshold Difference, δ_4	8.121***
Random Effect	*Variance Component*
u_{0j}	0.699***

†$p < .1$, *$p < .05$, **$p < .01$

Table 6. (Figure 8)

Fixed Effects	*Coefficient*
Outcome: *College Attendance Selectivity (USNEWS)*	
Intercept:, γ_{00}	-1.562
Economic, γ_{01}	0.024^{*}
Black, γ_{10}	1.301^{**}
Hispanic, γ_{20}	0.452
Asian, γ_{30}	0.045
Other, γ_{40}	0.139
Expected Degree, γ_{50}	$-0.311^{\dagger}$
Mathematics Sequence, γ_{60}	-0.792^{*}
Science Sequence, γ_{70}	$-0.497^{\dagger}$
Parent Education, γ_{80}	-0.049
Threshold Difference, δ_2	2.973^{***}
Threshold Difference, δ_3	5.172^{***}
Threshold Difference, δ_4	9.153^{***}
Random Effect	*Variance Component*
u_{0j}	0.653^{***}

$^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$

Table 7. (Figure 9)

Fixed Effects	*Coefficient*
Outcome: *Mathematics/Science Major (DSCIMAT)*	
Intercept:, γ_{00}	-3.501**
Female, γ_{10}	-0.156
Expected Degree, γ_{50}	0.253*
Mathematics Sequence, γ_{60}	0.330
Science Sequence, γ_{70}	0.468†

†$p < .1$, *$p < .05$, **$p < .01$

Table 8. (Figure 9)

Fixed Effects	*Coefficient*
Outcome: *Mathematics/Science Teacher (ALLMTHSCI)*	
Intercept:, γ_{00}	-8.775**
Female, γ_{10}	-0.047
Expected Degree, γ_{50}	0.574
Mathematics Sequence, γ_{60}	0.343
Science Sequence, γ_{70}	0.943

†$p < .1$, *$p < .05$, **$p < .01$

Table 9. (Figure 10)

Fixed Effects	*Coefficient*
Outcome: *Mathematics/Science Major (DSCIMAT)*	
Intercept:, γ_{00}	-3.196***
Female, γ_{10}	$0.375^{\dagger}$
Expected Degree, γ_{50}	0.138
Mathematics Sequence, γ_{60}	0.363
Science Sequence, γ_{70}	0.527
Random Effect	*Variance Component*
u_{0j}	$0.063^{\dagger}$

$^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$

Table 10. (Figure 10)

Fixed Effects	*Coefficient*
Outcome: *Mathematics/Science Teacher (ALLMTHSCI)*	
Intercept:, γ_{00}	-6.931*
Female, γ_{10}	0.590
Expected Degree, γ_{50}	0.138
Mathematics Sequence, γ_{60}	0.363
Science Sequence, γ_{70}	0.527
Random Effect	*Variance Component*
u_{0j}	0.475^{**}

$^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$