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

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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 positively related

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/science sequences than Black and

Hispanic students; consequently, many Black and Hispanic students slip off the pathway to

mathematics/science teaching before finishing high school. Although the percentage of males

and females majoring in mathematics and science in college is approximately equal at the

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

sophomore level, the students planning to teach mathematics or science are almost exclusively female.

Highly qualified mathematics and science teachers are the result of fortuitous opportunities and choices available along the pathway. Early interventions focused on better mathematics/science foundations for all students in elementary school will likely lead them to take higher level mathematics/science course sequences in middle and high school. Early counseling focused on fostering college aspirations and teaching as a career could be useful in promoting equity in educational attainment, teaching quality, and diversity in the mathematics/science teaching force. The current system normally waits until college entry to focus on the recruitment of teaching candidates. Waiting until college entry to focus attention on future teachers does not reach to the roots of teacher quality and equity.

Figure 1. The Pathway to Teaching

7. Teaching Mathematics/ Science to elementary, middle, or high school students

1. High School Students take course sequences in Mathematics /Science

2. Acceptance At colleges at colleges of different selectivities

3. Attendance at colleges of different selectivities

4. Majoring in Mathematics /Science in college

5. Deciding to teach Mathematics /Science in elementary, middle, or high school

6. Certification to teach Mathematics /Sciences for elementary, middle or high school

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

Demographics	Original Sample				
n	210001	169075	154673	48622	670
% of Original sample	100%	80.50%	73.70%	23.20%	0.30%
	1. High School Students	**2. Students Who Applied and Were Accepted at 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**
Male	48.0%	45.9%	45.4%	45.5%	9.1%
Female	52.0%	54.0%	54.5%	54.5%	90.9%
White	49.0%	51.3%	52.8%	50.1%	53.3%
Black	10.0%	10.3%	10.0%	9.7%	9.9%
Hispanic	33.0%	30.5%	28.6%	28.4%	13.0%
Asian	4.0%	4.0%	4.6%	7.7%	0.0%
Other (includes missing)	4.0%	3.9%	3.9%	4.0%	23.8%
Math course sequence					
Minimum	9.5%	6.7%	6.1%	4.2%	0.0%
Recommended	41.8%	37.0%	35.3%	25.8%	29.6%
Recommended Plus	47.9%	55.4%	57.7%	68.8%	70.4%
Distinguished	0.8%	0.9%	0.9%	1.1%	0.0%
Science course sequence					
Minimum	11.6%	8.4%	7.8%	3.7%	3.2%
Recommended	32.5%	31.1%	30.7%	24.4%	14.0%
Recommended Plus	54.1%	58.5%	59.3%	68.1%	55.7%
Distinguished	1.8%	2.0%	2.2%	3.8%	27.0%
Expected degree					
High School or less	3.8%	1.7%	1.2%	0.6%	0.0%
Some college to 2 years	14.3%	11.3%	9.9%	9.5%	10.9%
College graduate (4 years)	33.6%	34.7%	34.0%	26.4%	40.0%
Graduate or professional degree	48.3%	52.3%	54.9%	63.5%	49.1%
Parental Education Level					
High School or less	31.4%	26.6%	23.5%	24.7%	17.9%
Some college to 2 years	26.9%	27.6%	28.0%	26.2%	37.0%
College graduate (4 years)	23.1%	25.4%	26.9%	24.4%	21.8%
Graduate or professional degree	18.6%	20.4%	21.6%	24.6%	13.3%

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

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
n		210001	169075	154673	48622	670
% of Original sample		100%	80.5%	73.7%	23.2%	0.3%
Level 1. Student Characteristics						
Math course sequence	0-4	1.40(.67)	1.50(.63)	1.53(.62)	1.67(.57)	1.70(.46)
Science course sequence	0-4	1.46(.72)	1.54(.68)	1.56(.67)	1.72(.59)	2.07(.73)
Parental Education	0-8	4.67(1.88)	4.85(1.84)	4.97(1.8)	5.00(1.85)	4.74(1.34)
Desired extent of schooling (High School)	0-5	3.42(1.28)	3.58(1.13)	3.66(1.08)	3.87(1.06)	3.63(.97)
Highest selectivity accepted	1-5	-	3.40(.83)	3.41(.82)	3.46(.84)	3.57(.50)
Highest selectivity attended	1-5	-	-	3.08(.88)	3.14(.90)	3.36(.48)
Expected degree (College)	0-5	-	-	3.71(.92)	3.80(.90)	3.79(.84)
Level 2. High School Characteristics		n=91	n=91	n=91	n=56	n=49
% Economic disadvantage		35.07(20.92)	35.07(20.92)	35.07(20.92)	-	-
% Taking AP courses		12.11(10.82)	12.11(10.82)	12.11(10.82)	-	-
Total dropout rate	0-5	1.46(1.22)	1.46(1.22)	1.46(1.22)	-	-
Level 2. College Characteristics						
Teacher production intensity	13-860	-	-	-	198.69(199.62)	218.42(205.68)
US News rank	1-5	-	-	-	2.86(.84)	2.87 (.84)

Figure 2. Demographic shifts along the pathway to teaching

On the Pathway to Teaching Mathematics/Science   **Off the Pathway**

Did not graduate from High School – 2,766 (1.3%)
Did not go to college – 51,128 (24.3%)
% Male   % Female
9.8% White   11.8% Hispanic
2.5% Black   .4% Asian

Full High School Sample – 210,001 (100%)
48% Male   52% Female
49% White   33% Hispanic
10% Black   4% Asian
 4% Other

Military plans - 1,434 (.7%)

Have not decided – 16,217 (7.7%)
Do not know - 715 (0.3%)
Other/Missing – 16,085
% Male   % Female
% White   % Hispanic
% Black   % Asian

Attend college – 154,673 (73.7%)
45.4% Male   54.5% Female
52.8% White   28.6% Hispanic
10.0% Black   4.6% Asian
 3.9% Other

Non-Math/Science Related Majors – 73,035 (35.0%)
43.4% Male   56.4% Female
53.9% White   28.2% Hispanic
11.0% Black   3.0% Asian
 3.8% Other

Math/Science Related Majors – 48,622 (23.2%)
45.5% Male   54.5% Female
50.1% White   28.4% Hispanic
 9.7% Black   7.7% Asian
 4.0% Other

Other/Missing – 534 (1.1%)

Math/Science Related Majors Of 4 Yr Col. –
29,846 (14.2%)
51.1% Male   48.9% Female
53.8% White   21.9% Hispanic
10.6% Black   9.3% Asian
 4.3% Other

Math/Science Related Majors Of 2 Yr Col.
– 18,242 (8.7%)
36.5% Male   63.5% Female
44.9% White   38.2% Hispanic
 8.3% Black   5.1% Asian
 3.6% Other

Declared Math/Science Teachers - 670 (0.3%)
 9.1% Male   90.9% Female
53.3% White   13.0% Hispanic
 9.9% Black   0.0% Asian
23.9% Other

Other Math/Science Careers – 47,952 (0.3%)
Male   Female
White   Hispanic
Black   Asian
Other

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

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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

Before we can answer our main research questions, we must find out which students are taking what levels of mathematics and science course sequences. Therefore, there are five critical junctures along the pathway to teaching represented in this data that need to be analyzed. 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 these time points followed by two level hierarchical ordinal regression to determine the probability of improving one's status by increasing one's expected educational attainment level or taking higher course sequences.

We will first discuss the demographic patterns followed by 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 present 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 three 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.

The third limitation involved aspiring teacher sample size.   n was insufficient to carry out the two level HLM for race/ethnicity, degree aspirations, and course sequences predicting teaching mathematics or science. A multidimensional cross tab analysis was substituted.

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%
	$\chi^2 = .000$ $\eta = .032$		$\chi^2 = .000$ $\eta = .210$				

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%

$$\chi^2 = .000 \qquad \chi^2 = .000$$
$$\eta = .009 \qquad \eta = .016$$

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.
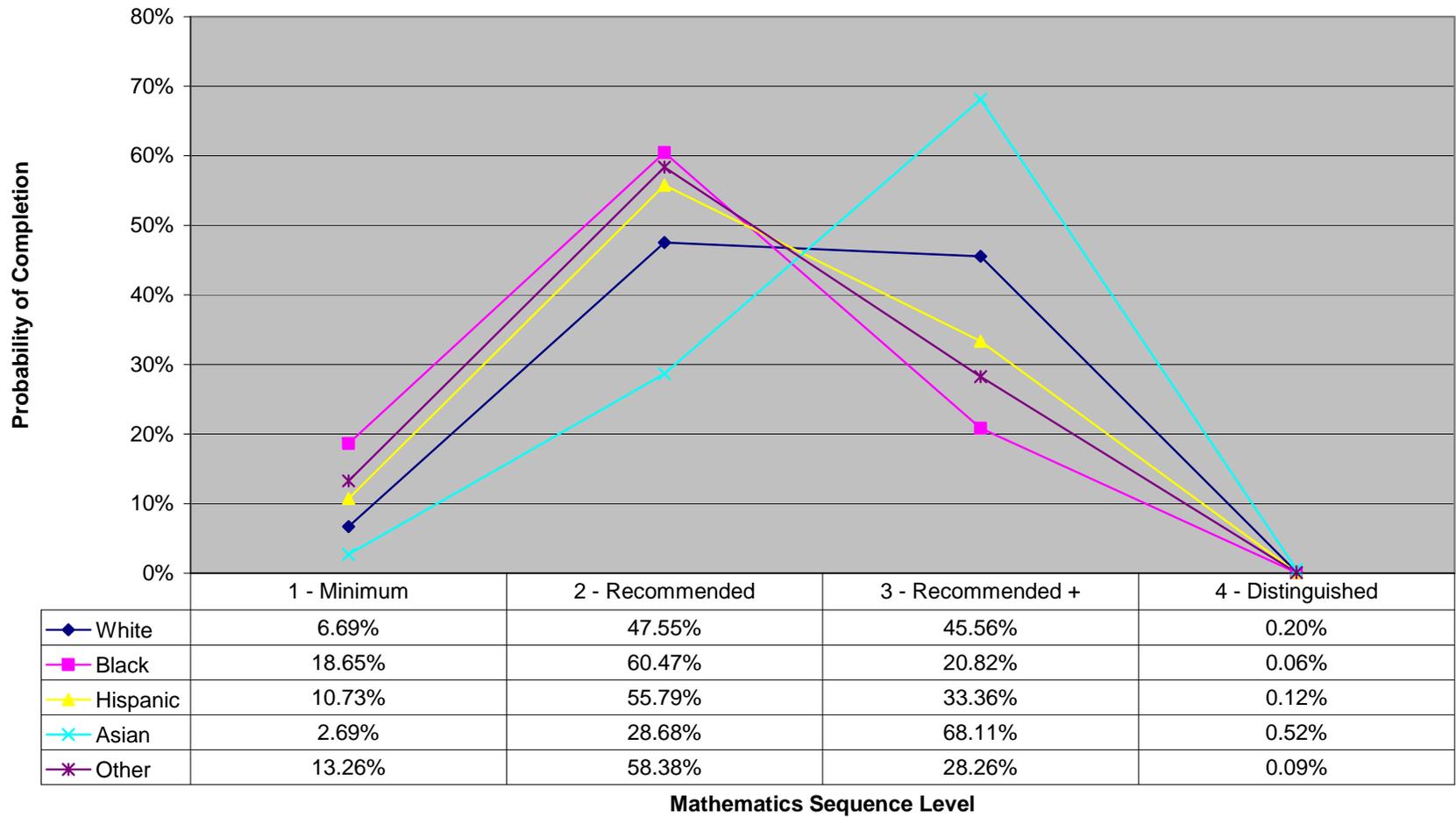
The demographic distribution of course sequences is not "new" news in Texas. It only underlies what we know already about the distribution of equality of access to education in the United States. More important is to discover the predictors of this distribution so that we might determine the factors 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 98% due to the large number of students within high schools. 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 were significantly different from zero at $p<.001$ with the exception of Other at $p<.01$. Figure 3 shows the results of the analysis by race and gender 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 School Economic Disadvantage

	1 - Minimum	2 - Recommended	3 - Recommended +	4 - Distinguished
White	6.69%	47.55%	45.56%	0.20%
Black	18.65%	60.47%	20.82%	0.06%
Hispanic	10.73%	55.79%	33.36%	0.12%
Asian	2.69%	28.68%	68.11%	0.52%
Other	13.26%	58.38%	28.26%	0.09%

Mathematics Sequence Level

In the analysis, Black students are 3 times more likely and Hispanic students are 1.7 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 2.6 times as likely to be in the minimum course sequence when compared to Asian students.
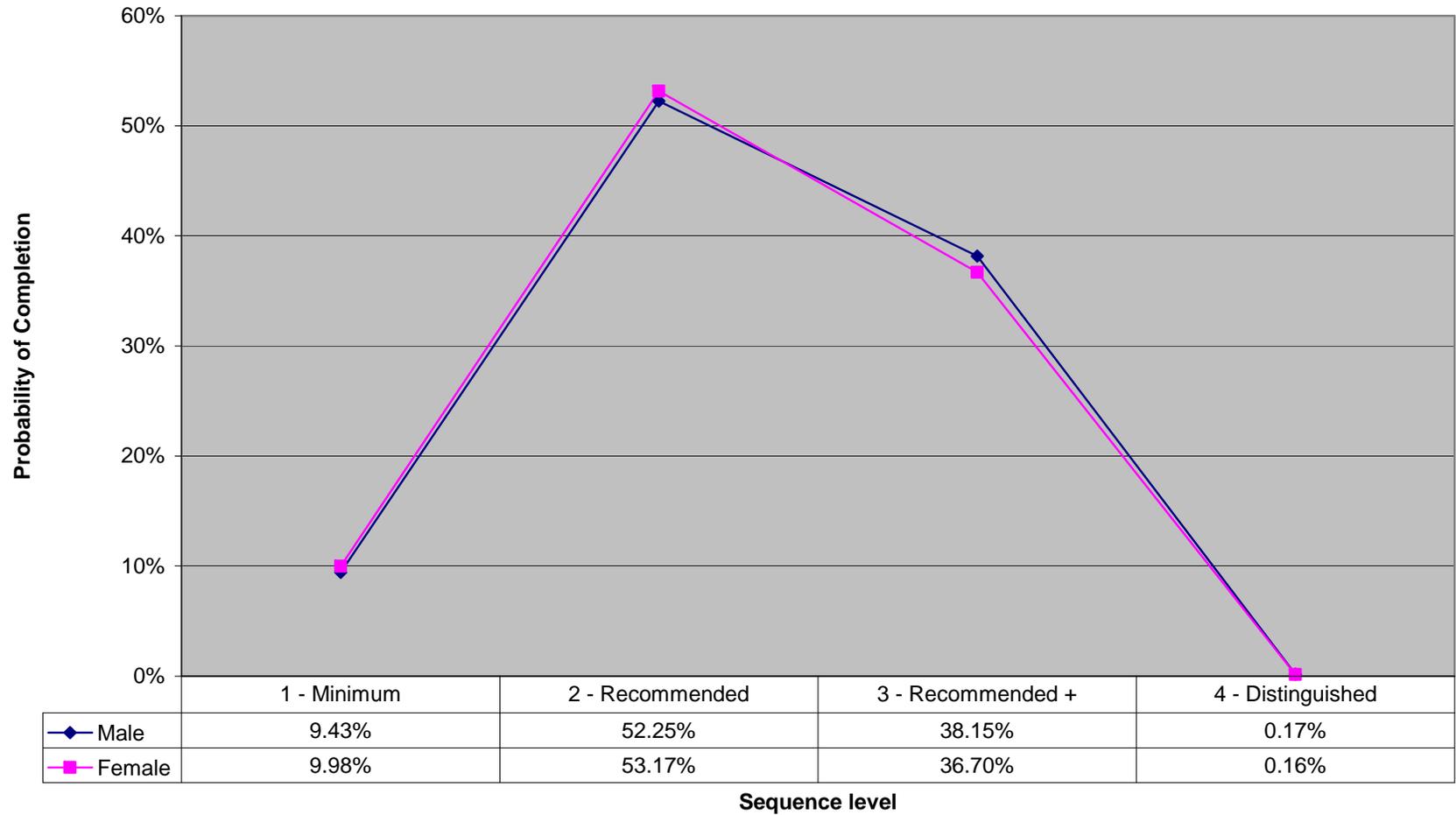
Black students are 1.6 times and Hispanic students 1.4 times more likely to complete the recommended course sequence compared to White students controlling for parental education level, degree aspirations, and high school economic disadvantage when compared to other groups. White students are 2.3 times more likely to fall in the recommended sequence than Asian students.

White students are 3.2 times more likely to be in recommended plus level compared to Black students and 1.7 times more likely than Hispanic students. Asian students are 2.6 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.
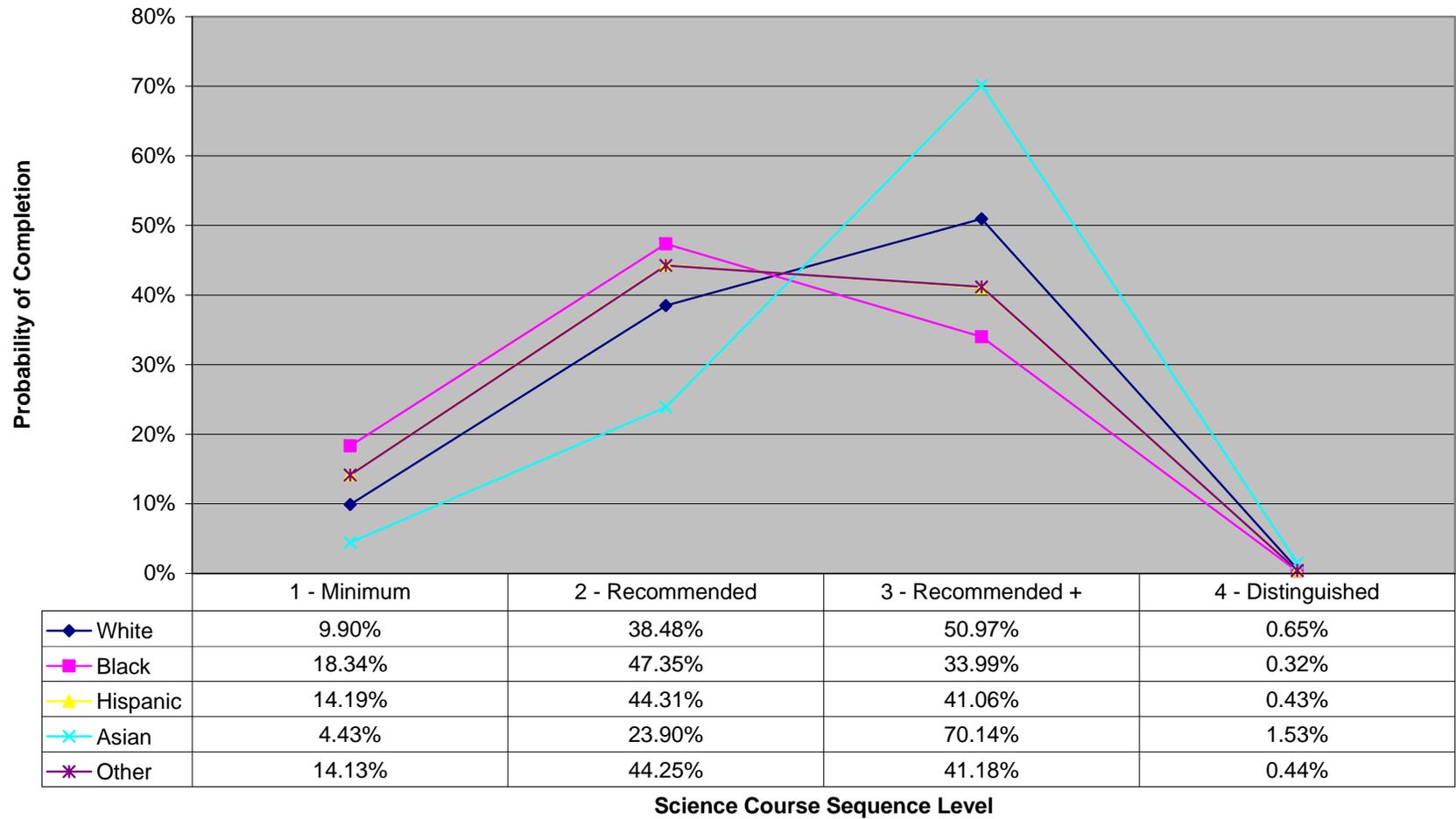
Figure 4. Probability of Completing a Mathematics Course Sequence By Gender Controlling for Mean Parental Education, Student Degree Aspirations, and School Economic Disadvantage

	1 - Minimum	2 - Recommended	3 - Recommended +	4 - Distinguished
Male	9.43%	52.25%	38.15%	0.17%
Female	9.98%	53.17%	36.70%	0.16%

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 School Economic Disadvantage
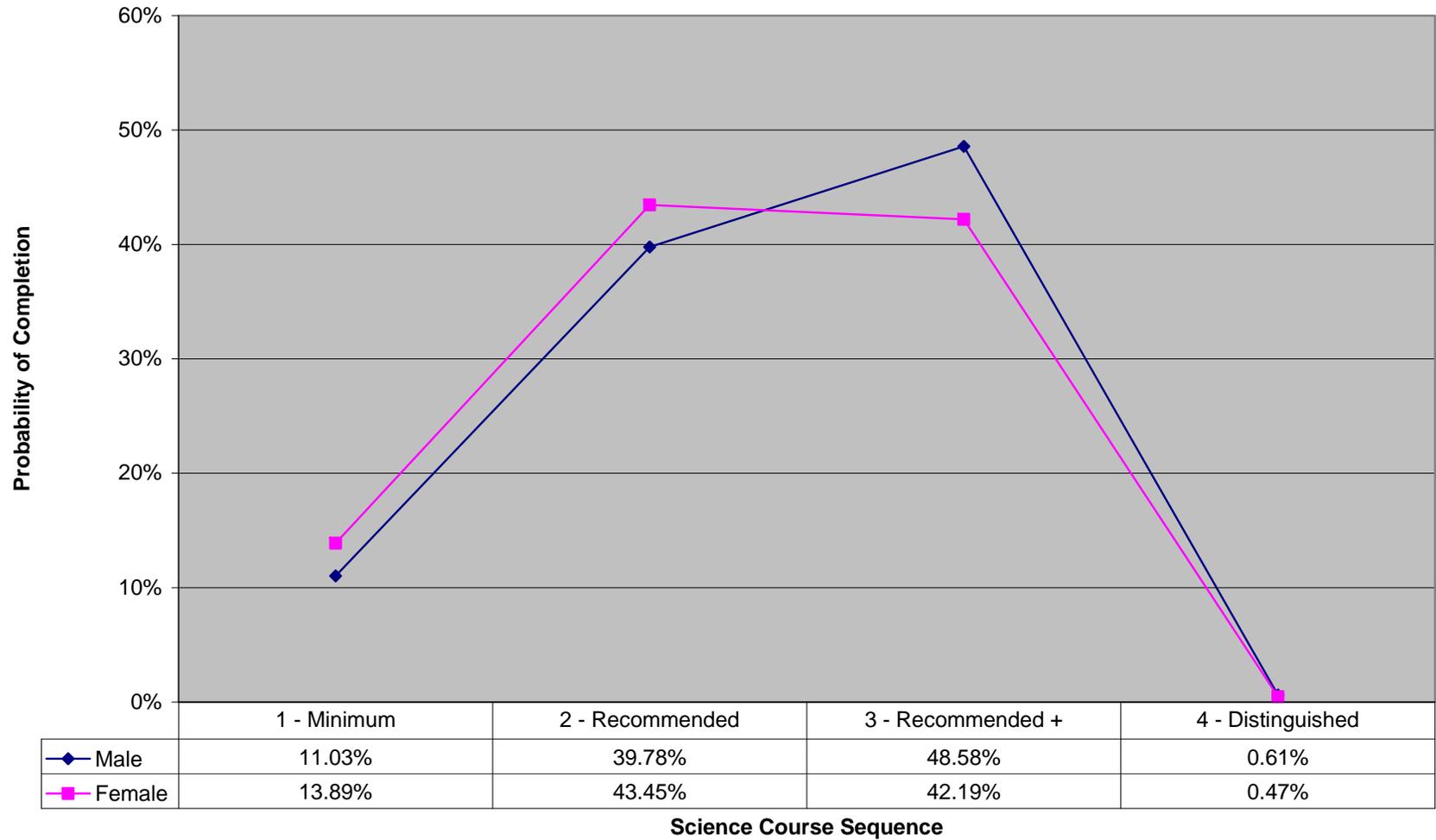
	1 - Minimum	2 - Recommended	3 - Recommended +	4 - Distinguished
White	9.90%	38.48%	50.97%	0.65%
Black	18.34%	47.35%	33.99%	0.32%
Hispanic	14.19%	44.31%	41.06%	0.43%
Asian	4.43%	23.90%	70.14%	1.53%
Other	14.13%	44.25%	41.18%	0.44%

Science Course Sequence Level

Trends are similar to mathematics although students are more likely to take higher course sequences in science than in mathematics. All coefficients are significantly different than zero with the exception of the coefficient for Other. The analysis controlled for parental education level, degree aspirations, and high school economic disadvantage. Black students are 2 times more likely and Hispanic students 1.5 times more likely to complete the minimum science course sequence as compared to White students. White students are 2.4 times more likely to be in the minimum course sequence compared to Asian students.

White students are more likely (1.4 times) to be in the recommended course sequence compared to Black students and 1.3 times more likely than Hispanic students. The odds for White students to be in the Recommended Plus or Distinguished science course sequence increase to 1.5 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

	1 - Minimum	2 - Recommended	3 - Recommended +	4 - Distinguished
◆— Male	11.03%	39.78%	48.58%	0.61%
■— Female	13.89%	43.45%	42.19%	0.47%

Science Course Sequence

As Table 4 illustrates, females are 1.2 times more likely to complete the recommended course sequence than males while males are 1.4 times more likely to complete the recommended plus course sequence controlling for parental education level, degree aspirations, and high school economic disadvantage. The coefficient for female is significantly different from zero when predicting the level of science course sequence.

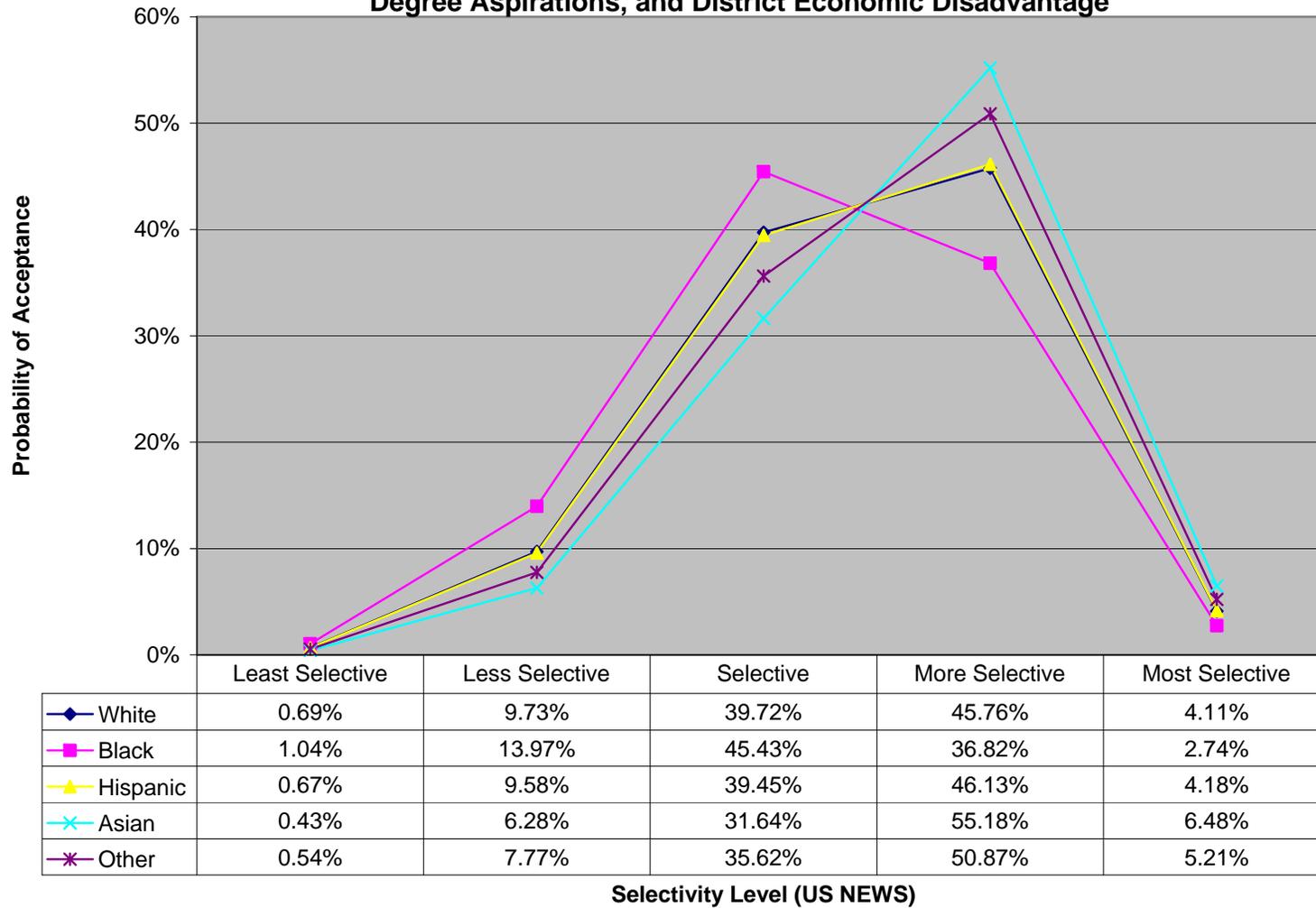**DETERMINANTS OF ACCEPTANCE AND ATTENDANCE BY COLLEGE SELECTIVITY LEVEL**

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 tend to be 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 than 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 colleges of the same level. The simple distribution of college-going students alone, again does not tell the whole story.

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 Mathematices/Science Course Sequences Controlling for Mean Parental Education, Student Degree Aspirations, and District Economic Disadvantage

	Least Selective	Less Selective	Selective	More Selective	Most Selective
White	0.69%	9.73%	39.72%	45.76%	4.11%
Black	1.04%	13.97%	45.43%	36.82%	2.74%
Hispanic	0.67%	9.58%	39.45%	46.13%	4.18%
Asian	0.43%	6.28%	31.64%	55.18%	6.48%
Other	0.54%	7.77%	35.62%	50.87%	5.21%

Selectivity Level (US NEWS)

Science course sequences in high school significantly predict college selectivity level: as students complete higher science course sequences, they are more likely to be accepted at more selective colleges. Mathematics course sequences, however, 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 and higher parental education levels 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 so this category is not reported to avoid extremely biased estimates.
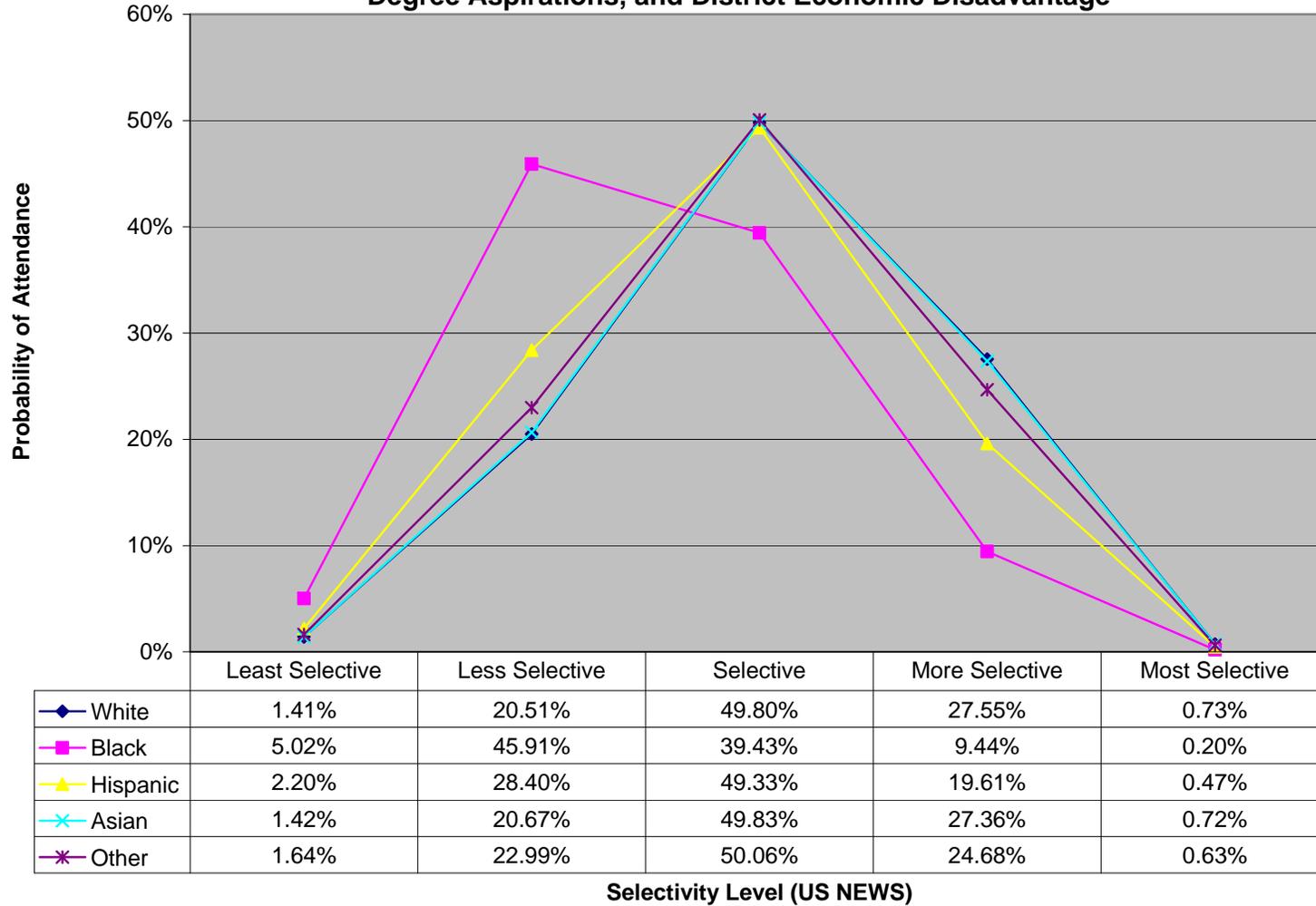
After controlling for mean values of anticipated degree, parental education, mathematics course sequence, science course sequence, and high school economic disadvantage, Black students were more likely than White students to be accepted at the least selective (1.5), less selective (1.5), and selective colleges (1. 3). They were less likely to be accepted (0.3) in more selective colleges than White students. In other words, Black students were more likely to be accepted into less selective colleges than White students, controlling for course sequencing and demographic variables.

Asian students were 1.5 times more likely to be accepted into more selective colleges than White students. The differences between Black and White students and between Asian and White students were statistically significant but the very small differences between Hispanic and White 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 Mathematices/Science Course Sequences Controlling for Mean Parental Education, Student Degree Aspirations, and District Economic Disadvantage

	Least Selective	Less Selective	Selective	More Selective	Most Selective
White	1.41%	20.51%	49.80%	27.55%	0.73%
Black	5.02%	45.91%	39.43%	9.44%	0.20%
Hispanic	2.20%	28.40%	49.33%	19.61%	0.47%
Asian	1.42%	20.67%	49.83%	27.36%	0.72%
Other	1.64%	22.99%	50.06%	24.68%	0.63%

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. Unlike the results for acceptance, parental education level was no longer predictive of college attendance.

As in the acceptance analysis, the odds ratios comparisons were reported for four college attendance selectivity categories (least selective, less selective, selective, and more selective). Controlling for gender and 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 college attendance compared to White students. Black students were 3.7 and 3.3 times more likely to attend least selective and less selective colleges than White students, and they were 0.3 and 0.7 times less likely in selective and more selective colleges than White students. Differences for both Asian and Hispanic students when compared to White students were not statistically significant.

In comparison to the acceptance model, the entire distribution has shifted toward the left, somewhat reminiscent of a bell curve. 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

Community college students are once again included in the following analyses. Until they make a choice to stop their education, they are still potentially on the pathway to majoring

in and teaching mathematics or science. As students attend college and choose majors, race/ethnicity is no longer a significant factor in predicting mathematics and science majors or those who become mathematics/science teachers. Gender becomes the most salient demographic in predicting which students become majors and teachers. High school course sequences and degree aspirations are significantly related to choosing majors but other factors appear to be at work when choosing to teach.

At the university level, the outcomes for major and teaching science or mathematics are binary rather than categorical. In HLM, the unit specific outcomes yield the closest results to the prior ordinal analyses. Figure 9 illustrates the gender distribution of mathematics and science major and mathematics and science teaching. The graph is followed by the results from a multidimensional scaling analysis of mathematics and science teachers.

Figure 9. Mathmatics/Science Major & Teacher by Gender Controlling for Course Sequences, Parental Education and Student Aspirations

	Mathematics/Science Major	Mathematics/Science Teacher
Male	36.05%	0.00%
Female	22.60%	42.34%
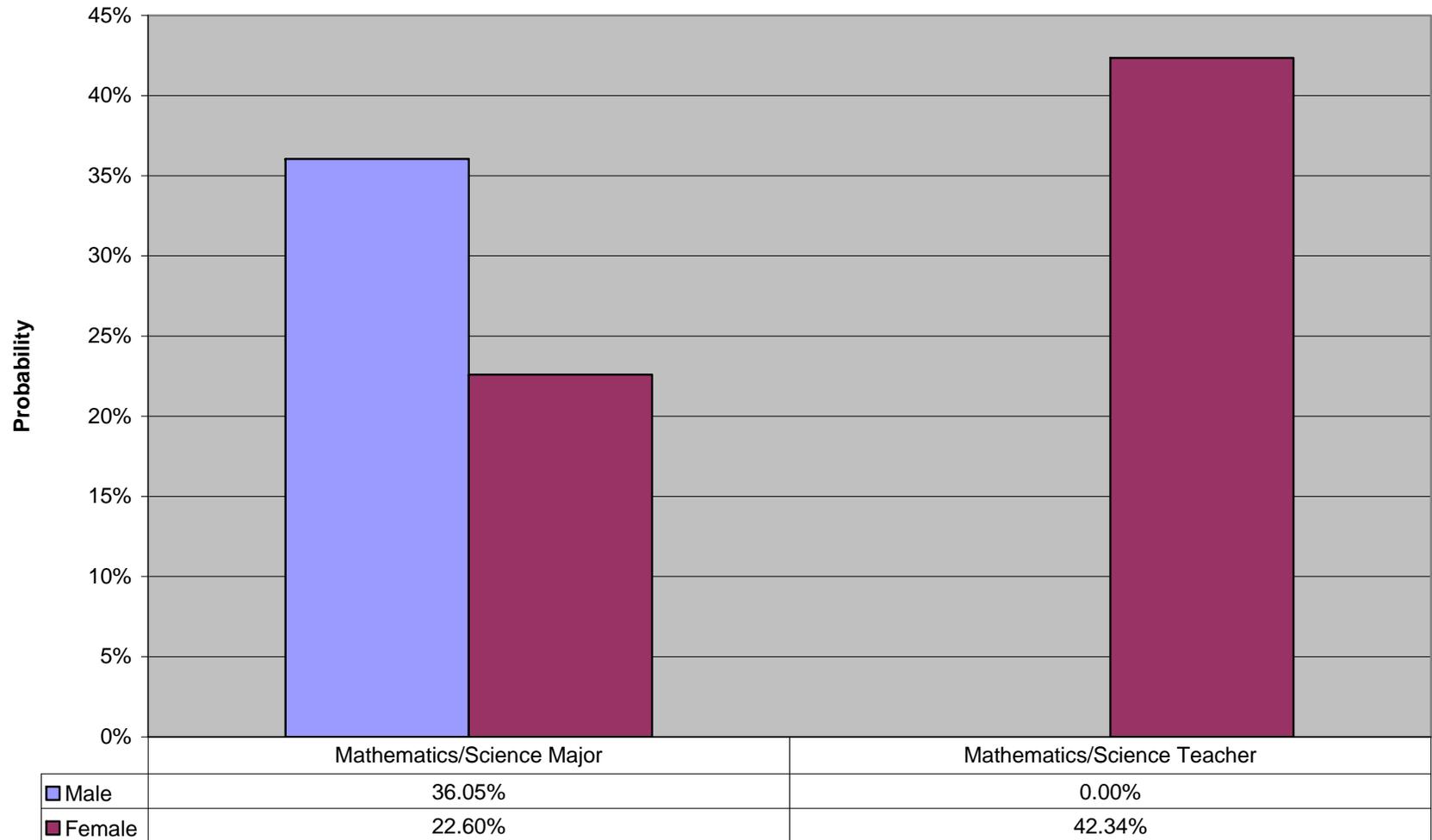
Males are almost twice as likely to major in mathematics or science as females but females overwhelmingly plan to teach mathematics and science compared to males when controlling for anticipated degree, parental educational, mathematics course sequence, science course sequence, college selectivity and teacher production. A multidimensional cross tab, which does not control for any other variables, reveals that out of the 48,625 students planning mathematics and science related careers, 670[2] are anticipating mathematics or science teaching by the middle of the college sophomore year. Several cells were missing data so HLM was not able to compute the mathematics and science teacher analysis.

Table 5 presents the percentages of teacher by gender and race/ethnicity from the multidimensional crosstabs analysis side-by-side with original sample proportions. This allows the comparison of aspiring teacher demographics to be compared with the demographics of the Texas student population in 2002.

Table 5. Percent of aspiring teachers compared to original sample demographics

	% aspiring teachers	% original population
Male	9.10%	48.00%
Female	**90.90%**	**52.00%**
White	47.13%	49.00%
Black	11.15%	10.00%
Hispanic	**14.70%**	**33.00%**
Asian	0.00%	4.00%
Other	27.03%	4.00%

Fewer than one in ten of these aspiring teachers are male and none are Asian. On average, Hispanic and White aspiring teachers took "recommended" or "recommended plus" mathematics and science high school sequences. Black aspiring teachers took the "minimum" and "recommended" course sequences in high school, one sequence level lower than their

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[2] It is very likely that some of the students pursuing mathematics and science related majors will decide to become teachers and vice versa. This data was collected at an early point in the college career. Wave 3 (senior year) data, when available, will provide a more complete picture of those who persist in becoming teachers.

White/Hispanic counterparts. In terms of college selectivity, aspiring teachers went to schools of similar selectivity to other mathematics and science majors but were more apt to attend schools with higher teacher production.

DISCUSSION

There are both negative and positive findings that lead us to our conclusions regarding quality and equality on the pathway to mathematics and science teaching in Texas. There are indications that race and gender are related to inequality at various points along the pathway and that this inequality has implications for quality in the teaching force. Differences among racial/ethnic groups are not sufficiently explained by background factors such as parental education level or school economic disadvantage. On the positive side, there are indications that the solution to some of the inequality issues may lie in the hands of the students themselves.

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 do attend college at higher within category percentages. Controlling for high school economic disadvantage and parental education does not explain the differences in science and mathematics sequence patterns among the groups of students.

When looking at patterns of acceptance and attendance at colleges of different selectivity levels, Black students with similar qualifications to other students are more likely to trail their classmates in college selectivity levels. Hispanic students with similar qualifications are more

likely to attend "less selective" colleges and less likely to attend "more selective" colleges (although they do attend "selective" colleges with the similar probability) compared to their White and Asian peers. In this analysis, the Black and Hispanic students are disproportionally affected in the selectivity of college acceptance and attendance but they have the <u>same</u> 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 determining factor in the decision to major in mathematics or science. High school mathematics and science course sequences and degree aspirations continue to predict majors in those subjects. At this point on the pathway, gender becomes the significant demographic characteristic that stratifies those who major in mathematics and science and those who do not. It is no surprise that males are twice as likely as females to major in mathematics or science when sequences and degree aspirations are controlled.

Of the nearly 48,700 mathematics and science majors, only 670 are considering teaching the subjects and this group is predominantly female. In terms of candidate quality, those considering teaching have similar if not slightly higher qualifications than other mathematics and science majors.

When it comes to diversity in the future teaching force, Texas will have few male mathematics and science teachers as role models. K-12 students will be taught mathematics and science primarily by women. In terms of the racial/ethnic distribution of teachers, there will be few, if any Asian teachers and the percentage of Hispanic teachers will lag far behind the distribution of Hispanics in the population. The science and mathematics teaching force will not effectively reflect the diversity of Texas.

On the positive side, student 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, a combination of higher degree aspirations and higher course sequences in high school shows promise for mediating the effects of low parental education and school economic disadvantage for all students when it comes to college acceptance, attendance, and majoring in mathematics and science.

CONCLUSIONS

Taking higher mathematics and science course sequences in high school is positively related to acceptance, to attendance, to majoring in mathematics and science in college and ultimately determines who will be in position to choose teaching those subjects as a career. Possible strategies for recruiting students into science and mathematics fields include: 1) providing high quality mathematics and science instruction in elementary and middle schools so all students are prepared to attempt rigorous mathematics and science course sequences in high school; 2) encouraging higher degree aspirations, 3) encouraging higher course sequences that lead to acceptance and attendance at more selective colleges.

Increasing the number and diversity of highly qualified mathematics and science teachers will be more 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. 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.

In addition, it is possible that waiting until college to recruit future teachers is not as

effective as recruiting earlier. Programs aimed at increasing the diversity and quality of the

teaching pool could begin before students take the course sequences that limit their future

opportunities.

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