The Path to Math: Gender and Racial-Ethnic Differences in Mathematics Participation from Middle School to High School

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This study traced the development of gender differences in learning opportunities, achievement, and choice in mathematics among White, African American, and Latino students using data from a nationally representative sample of eighth-grade students who were resurveyed in the 10th grade. It found that in this age group, female students do not lag behind male students in test scores and grades and that White female students are exposed to more learning opportunities in mathematics than are male students. However, all female students tend to have less interest in mathematics and less confidence in their mathematics abilities. Gender differences are the largest among Latinos and the smallest among African Americans. Furthermore, the major barriers to mathematics achievement for White female students are attitudes and career choices and for minority students of both sexes, they are limited learning opportunities and low levels of achievement.

Women still trail men in their participation in mathematics and related fields (Friedman 1989; Marsh 1989; National Science Foundation, NSF, 1988; Sadker, Sadker, and Klein 1991). Oakes (1990) provided a useful conceptualization for explaining this gender gap: "opportunities, achievement, and choice." In mathematics, women's limited involvement in learning opportunities, relatively low levels of achievement, and lack of interest eventually affect their underrepresentation in the field. Logically, if the opportunity structure benefits men, one should be able to identify some mechanisms of disadvantage by documenting differences between males and females in these three conceptual areas.

Gender differences in the domains of opportunity, achievement, and choice emerge during the middle grades, but little is known of the exact and developmental nature of their interrelationship (Oakes 1990). This lack of knowledge is due mainly to limitations in research that has not been longitudinal in scope, generalizable in extent, and ethnic-race specific (Clewell and Anderson 1991; Oakes 1990).

Berryman (1983), for example, discussed these limitations when she suggested that girls' interests and career choices before ninth grade may develop independently of their achievements. The relationship between interests and achievement may differ for older students, since in high school, career choices and attitudes toward academic subjects may influence participation in the more advanced elective courses. Berryman cautioned, though, that these conclusions were tentative because they were based on data that may not be generalizable.

To be certain of the causal direction between and the relative importance of opportunity, achievement, and choice, one needs nationally representative longitudinal data that measure students from the middle grades on, when the pool of mathematics and science talent is formed (Berryman, 1983; Oakes 1990). With the addition of an oversampling of minority students, one could examine the relative contributions of each of these conceptual domains for all students who remain underrepresented in mathematics and other quantitative fields (Berryman 1983; Clewell and Anderson 1991; Oakes 1990). Most research has focused on gender differences in general, and for that reason the portrayal of any one group is inaccurate (Oakes 1990). In thinking about equity, one needs research that investigates the "path to math" for different types of women and men. It is only since 1988 that nationally representative data bases satisfying these conditions have been available.

This article reports on a study that used data from a large, national survey to examine race- and ethnic-specific gender differences in a cohort of eighth-grade students. The aim of the study was to explore the process by which women's participation in mathematics begins to drop during adolescence, by tracing students' mathematics-related learning opportunities, attitudes, and achievements from middle school to the early years of high school.

EMERGENCE OF GENDER DIFFERENCES

Although gender differences in mathematics achievement are most evident during secondary and postsecondary education, they may develop much earlier (Kahle and Lakes 1983; Steinkamp and Maehr 1984). For middle school students, gender differences in performance and course work are minimal, but strong differences exist in attitudes and perceptions of the usefulness of mathematics (Lockheed, Thorpe, Brooks-Gunn, Casserly, and McAloon 1985; Oakes 1990). For example, beginning in middle school, girls show less interest in mathematics and science and have more negative attitudes toward these fields. They have relatively high levels of performance anxiety and little confidence in their personal abilities, and they attribute their success to luck, rather than to their own efforts and abilities (Cross 1988; Fennema 1980, 1984; Fox 1980; Lockheed et al. 1985; Norman 1988; Schronberger 1980). Girls' negative attitudes toward mathematics and limited academic confidence may influence their later career choices and steer them away from mathematics-related fields.

Some researchers (see, for example, Steinkamp and Maehr 1984) who investigated students' attitudes toward mathematics in the middle school years suggested that gender differences emerge partly as a result of the new learning environment that students face when they enter middle school. At this level, students are exposed to a greater number of male teachers and to a more competitive and unstructured learning environment that may undermine girls' self-esteem and confidence in their academic abilities. Therefore, this new learning environment could contribute to subsequent inequalities in male and female students' performance and participation in mathematics during high school, when students can choose advanced mathematics courses as electives. Also at the middle school level, little is known about gender differences in learning opportunities (such as course work, ability-group placement, and extracurricular activities) and how such learning opportunities are related to students' further achievements and attitudes.

At the high school level, young women often limit their opportunities to learn mathematics by completing only the minimal mathematics courses required for graduation (Fox 1980; Fennema 1984; Norman 1988; Reyes 1980). Women's inadequate participation in mathematics courses during high school explains a substantial part of the gender differences in mathematical achievement (Berryman 1983; Fennema 1980; Jones 1987; Oakes 1990; Pallas and Alexander 1983; Smith and Walker 1988).

Unlike research on middle school students, studies of high school students have made some attempt to link opportunities to learn through participation in courses to gender differences in mathematics achievement. The causal direction in the relationship between learning opportunities, achievement, and attitudes remains unclear, however (Oakes 1990). One might assume that female students participate less in learning opportunities and do less well in mathematics because they are not interested in this subject. It is also possible that female students develop negative attitudes toward mathematics because of their relatively low levels of achievement and limited participation in learning opportunities.

Race and Ethnic Variations

Studies of developmental differences in opportunities, achievement, and choice by gender may be further qualified for race and ethnicity; women of color are the most underrepresented group in mathematics and science, but few researchers have specifically studied their educational experiences. The literature generally treats race and ethnicity by excluding gender as a variable or does not focus on what stage in a student's education gender and racial or ethnic interactions occur (Clewell and Anderson 1991; Lockheed et al. 1985).[1]

Some research has found that African American and Latino students tend to have positive attitudes toward mathematics, despite their low levels of achievement in the subject (Clewell and Anderson 1991; Mickelson 1990; Oakes 1990). Thus, the relationship between achievement in mathematics and attitudes toward this subject may not exist for all groups of students.

The few studies that have been done have indicated that female minority students perform poorly on mathematics achievement tests. Minority students, in general, participate in few learning opportunities, such as extracurricular activities and advanced course work, in mathematics (Clewell and Anderson 1991). Therefore, these students decrease their opportunities for further course work in high school and for careers in scientific and quantitative fields (Clewell and Anderson 1991).

Among African Americans, gender differences in mathematics achievement and course participation either do not exist or favor female students (Clewell and Anderson 1991; Mathews 1984). If indeed such findings are confirmed through nationally representative data, the generalization that young women underachieve in mathematics in relation to young men may misrepresent the educational experiences of the variety of students who attend our nation's schools. The interrelationships among the conceptual domains of opportunity, achievement, and choice, as well as gender differences in each domain, may vary considerably according to students' racial or ethnic backgrounds.

The study presented here sought to advance understanding of the processes leading to inequities in participation in mathematics by examining the development of differences in opportunity, achievement, and choice for male and female students of specific racial and ethnic groups. I expected that the opportunity structure leading to participation in mathematics and related fields varies for these groups.

SOURCE OF DATA

I used data from the base year and first follow-up surveys of the National Educational Longitudinal Study of 1988 (NELS:88), sponsored by the National Center for Education Statistics. NELS:88 makes available survey and testing data for a national probability sample of eighth-grade students. Its design includes plans to resurvey these same students at two-year intervals (for detailed information on this data set, see Ingels, Scott, Lindmark, Frankel, and Myers 1992).

The NELS:88 sample is a two-stage

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[1] It may be assumed that differences in mathematics participation by race and ethnicity are grounded in the broader determinants of economic development, as cross-national studies (Baker and Perkins Jones 1993) found for gender differences. In the United States, educational and labor market opportunities may vary considerably according to race and ethnicity (Braddock 1990; Ogbu 1978). Ogbu found that castelike minority groups, such as those in African American and some Latino communities, face a job ceiling that does not permit them to obtain jobs that are commensurate with their educational credentials. The limited occupational and educational opportunity structures of these groups affect both their educational performance and their attitudes toward education.

stratified, nationally representative sample of approximately 1,052 schools and 24,500 students who were interviewed in 1988 and 1990. I used data from the base-year student, parent, and teacher surveys and the first follow-up student survey. The student surveys included information about the students' socioeconomic backgrounds, perceptions of self, school life and educational experiences, and career aspirations. The students also completed a battery of cognitive tests developed by the Educational Testing Service. The base-year parent survey yielded information about the nature and extent of parental support for students' educational activities. The base-year teacher survey probed teachers' perceptions of the sampled students' classroom performances, information about the curricular content of the teachers' classes, instructional methods and materials used, and teachers' backgrounds. Information from their mathematics teachers is available for about half the students in the sample.

Data analyses for this study were restricted to students attending public schools because a number of studies have indicated that differences in the academic and social organization of private schools, especially Catholic schools, influence students' academic behavior (Coleman and Hoffer 1987; Coleman, Hoffer, and Kilgore, 1982; Lee and Bryk 1988)[2] The base-year sample included approximately 19,000 students in public schools; of these students, approximately 14,000 were still enrolled in public schools in the 10th grade.[3]

VARIABLES

Measures of Opportunity, Achievement, and Choice

A number of variables were used to indicate these three domains.[4]

Mathematics achievement refers to students' scores on mathematics tests in the eighth and 10th grades and students' mathematics grades from the sixth to the 10th grade.

Learning opportunities in mathematics refers to (1) eighth-grade class ability levels, (2) the type of curriculum in which students are enrolled in the 10th grade, and (3) students' enrollment in Algebra I, Algebra II, and Geometry by the 10th grade. Regarding eighth-grade class ability levels, the mathematics teachers were asked to respond to the following question: "Which of the following best describes the achievement level of the eighth graders in this class in comparison with the average eighth-grade student in this school?—higher achievement levels, average, lower, or widely differing achievement levels."

Although the teachers' responses may be prone to some error regarding the existence of ability grouping, they generally tend to be more reliable than are the students' responses. Comparative analyses of teachers' and students' responses in the NELS:88 data revealed that minority and low-achieving students tended to underrepresent their placement in low-ability groups (Braddock and Mac Iver 1991). These discrepancies make the use of teachers' responses a more desirable alternative to students' self-reports.[5]

[2] Researchers have found that the academic orientation of Catholic high schools positively affects students' levels of mathematical achievement (Coleman et al. 1982; Lee and Bryk 1988) and that single-sex Catholic schools are particularly beneficial for the academic achievements of female students (Lee and Bryk 1986; Riordan 1990). Given these differences between public and private (Catholic) schools, investigating school-sector effects was beyond the scope of this study.

[3] All the data were weighted by the appropriate sampling weights provided by the National Opinion Research Center (BYQWT, F1PANLWT). The weights were standardized (for example, BYQWT/mean BYQWT) to obtain appropriate sample sizes for tests of significance.

[4] More detailed information on definitions of variables and descriptive statistics is available from the author on request.

[5] Mathematics teachers' responses to a question on the topics they covered in their classes also yielded information on learning opportunities of students in different ability classes. With regard to major instructional topics, the majority of students in high-ability classes are exposed to algebra (90 percent) and problem solving; students in average-ability classes are mainly exposed to ratios, percentages, integers, and problem

Choice and attitudes toward mathematics refer to eighth graders' aspirations to a mathematics- and science-related career, attitudes toward mathematics (whether students look forward to mathematics class, whether they are afraid to ask questions in mathematics courses, and whether they think that mathematics will be useful for their future), and a composite of students' participation in relevant extracurricular activities (mathematics and computer clubs). The 10th-grade survey did not repeat these items, but introduced new items regarding students' interests and judgments of their own performance in mathematics: student-reported reasons for enrolling in their mathematics course, a series of statements indicating students' perceptions of their performance in mathematics, and students' reports of how hard they try in mathematics classes.

Independent Variables

Social background characteristics refer to the student's socioeconomic status (a composite variable consisting of parents' education, occupation, and family income); parents' responses to whether they expect their eighth grader to attend postsecondary school; student's expectations for taking an academic high school curriculum; and the student's year of birth, gender, and racial and ethnic characteristics.

Eighth-grade teacher evaluation is a composite variable indicating teachers' ratings of each student's problematic classroom behavior.

RESULTS AND DISCUSSION

The analyses revealed several significant race- and ethnic-specific gender differences in opportunity, achievement, and choice for the eighth- and 10th-grade students.

Patterns for Eighth-grade Students

Achievement. Concerning achievement, male and female eighth graders tend to have similar scores on mathematics tests. This gender equity exists even when the girls receive better grades in mathematics, as is the case of White students (see Table 1).

At this stage of schooling, differences in mathematics achievement occur mostly among racial-ethnic groups, rather than between male and female students; girls perform equally well, or even better, in mathematics than do boys. The strongest gender differences, though, occur in learning opportunities, which are represented here by ability-group placement; placement in classes of different ability levels favors female, rather than male, students.

Learning opportunities. The indicator of learning opportunities shows that students of both genders are equally likely to enroll in average-ability mathematics classes. However, a higher proportion of girls are enrolled in high-ability classes, and a higher proportion of boys are enrolled in low-ability classes. These gender differences are fairly consistent among all three racial-ethnic groups, even though African American and Latino students are, in general, overrepresented in low-ability classes. White female students have the highest enrollment in high-ability classes, and African American male students have the highest enrollment in low-ability classes. These differences are important because they show that both female and White students have greater opportunities to learn mathematics, since they are more often exposed to the rigorous and demanding curricula of high-ability classes.

Unfortunately, the NELS:88 data set does not provide information on the criteria that schools use to assign students to ability groups. Students' performance on relevant achievement tests would be an important placement criterion, but given the lack of gender differences in this variable, it may not explain

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solving (and 57 percent cover algebra); and students in low-ability classes learn fractions, percentages, and ratios, but either cover algebra as a minor topic (39 percent) or are not taught algebra at all (24 percent). Information from the student survey also indicated that about 20 percent of the students in low-ability classes attend remedial mathematics at least once a week.

Table 1. Eighth-grade Mathematics Achievement and Learning Opportunities (Ability Grouping), by Gender and Race-Ethnicity

	White Students		African American Students		Latino Students	
	Male	Female	Male	Female	Male	Female
Mathematics Test Scores						
$\overline{X}$	51.54	51.36	43.42	43.67	45.90	44.69
(s)	(9.93)	(9.69)	(7.86)	(7.96)	(8.94)	(8.20)
Mathematics Grades (Grades 6–8)						
$\overline{X}$	3.87	3.96[a]	3.73	3.77	3.74	3.73[a]
(s)	(1.02)	(.99)	(1.05)	(1.04)	(1.11)	(1.09)
Average N	5,802	5,708	1,136	1,033	1,208	1,210
Ability-group Placement (percentage)[b]						
High	27.0	30.2	14.2	17.5	16.7	17.8
Average	39.9	39.6	32.3	32.7	40.0	40.9
Low	19.0	16.5	35.6	29.6	28.9	23.8
Mixed	14.1	13.7	18.0	15.7	14.5	17.4
N	2,862	2,797	552	570	582	563

[a] Gender differences statistically significant at $p < .05$.
[b] Chi-squares statistically significant at $p < .05$.

the female advantage in ability-group enrollment. It is possible that additional assignment criteria are used that tend to distinguish female students from their male classmates. Students' prior grades, their age (which indicates the probability of their having been retained in previous grades), and their classroom behavior may influence the decisions of school personnel. Girls, who are more diligent students and exhibit less-disruptive classroom behavior, may be placed in higher-ability groups than may boys. Students' socioeconomic background may also be an important factor that may influence the differential placement of male and female students, especially through parental involvement in school. Parents of high socioeconomic status tend to intervene effectively on behalf of their children's placement in high-ability tracks (Useem 1992a).

Female students' advantage in ability-group placement may be due to their diligence and serious academic efforts. This advantage may be particularly strong for girls of high socioeconomic backgrounds, whose parents can effectively intervene on their behalf. To examine further the relationship between students' gender and ability-group enrollment in mathematics, I conducted multivariate analyses to control for the aforementioned characteristics of students. I conducted logistic regression analyses on two dichotomous dependent variables: (1) enrollment in a high-ability mathematics class or not and (2) enrollment in a low-ability mathematics class or not (see Table 2). These variables represent the two ability levels for which gender differences in enrollment are mainly observed. The control variables are mathematics achievement and grades since the sixth grade, students' age and teachers' ratings of appropriate classroom behavior, type of high school curriculum in which students plan to enroll, parental expectations for college, and socioeconomic background and its interaction with students' gender.

Female students are still more likely to enroll in high-ability mathematics classes than are male students, even when the educational, social background, or social-psychological characteristics of students are held constant. This gender effect is statistically significant for White and African American students. The low level of statistical significance for African Americans could be explained by the relatively small size of this group in the sample. The chances of young women enrolling in high-ability mathematics classes are higher than are those of young men by about 25 percent for White and 48 percent for

Table 2. Logistic Regression Coefficients of Gender for Learning Opportunities (Ability Grouping) in Eighth-grade Mathematics[a]

	White Students	African American Students	Latino Students
	Exp (Beta) (gender)[b]	Exp (Beta) (gender)[b]	Exp (Beta) (gender)[b]
Enrollment in a high-ability group or not	1.25**	1.48*	1.22
Enrollment in a low-ability group or not	.87	.85	.77
N	5,070	956	970

* $p = .07$, ** $p < .01$.
[a] Logistic regressions control for the following variables: mathematics achievement and grades from the sixth to the eighth grade, mathematics teacher's rating of student's classroom behavior, socioeconomic status and its interaction with gender, type of high school curriculum planned by the student, age, and parents' expectations for attending college.
[b] Contrast category = male.

African American students (odds of 1/.75 and 1/.52, respectively). On the other hand, once students' educational and other background characteristics are taken into account, gender is no longer related to the probability of enrolling in low-ability classes. It is interesting to note that socioeconomic status and gender have no significant interactions for any of the three racial-ethnic groups. Actually, the effect of this interaction term was not statistically significant for most of the multivariate analyses presented in this article. In other words, within each racial-ethnic group, socioeconomic status is not related to gender differences in mathematics achievement or attitudes.

Assigning students to mathematics classes that are grouped by ability is a practice that has important consequences for students and is extensively used in the middle grades. Over 80 percent of school administrators report that they use ability grouping for eighth-grade mathematics classes (Braddock 1990). Given the cumulative nature of learning mathematics, enrollment in a high-ability class may influence students' academic preparation and future participation in mathematics (Gamoran 1987; Kulik and Kulik 1984; Useem 1992b). In high-ability classes, students receive more intensive academic training and are exposed more often to topics, such as algebra. These learning opportunities allow them to pursue a more rigorous mathematics sequence in high school and to gain access to quantitative and science-related college majors (Sells 1980; Useem 1992b). Thus, the advantage that White and African American females gain over comparable males by being placed in high-ability classes may be crucial for their participation in mathematics in high school and college.

Previous studies reported either no gender differences in ability-group placement and curriculum tracking or placement that favored male over comparable female students (Alexander and Cook 1982; Alexander, Cook, and McDill 1978; Alexander and McDill 1976; Hallinan and Sørenson 1987). It is possible that this trend was reversed in the late 1980s, since Gamoran and Mare (1989) found a similar advantage for females in enrollment in the academic curriculum in high school.

Choice. Measures of choice of and attitudes toward mathematics show that young women's persistence in advanced mathematics course work during high school may actually depend on their earlier decisions about careers and attitudes toward this subject. By the eighth grade, fewer female students than male students have decided to pursue mathematics and science careers (see Table 3). Students' career choices show strong gender differences among all three racial-ethnic groups. Although few students are interested in mathematics- and science-related careers, twice as many male students as female students are interested. Female African American and Latina students are the least likely to aspire to such careers, and White male students are the most likely to do so.

Male students also have more positive

Table 3. Measures of Eighth-grade Choice, by Gender and Race-Ethnicity

	White Students		African American Students		Latino Students	
	Male	Female	Male	Female	Male	Female
Career Aspirations for a Mathematics/Science-related Field						
% aspiring	8.5	3.4[a]	5.3	2.4[a]	6.3	2.5[a]
Attitudes toward Mathematics (percentage of students who agree)						
I Look forward to math class	54.8	51.3[a]	72.2	68.5[b]	67.8	59.6[a]
Afraid to ask questions in math class	17.0	22.6[a]	22.3	21.5	24.9	32.6[a]
Math will be useful in my future	88.6	86.5[a]	90.0	88.0	89.6	89.4
Extracurricular Activities						
% participating in math or computer clubs	9.2	6.2[a]	16.4	14.8[a]	15.7	9.5[a]
Average N	5,976	5,997	1,121	1,218	1,286	1,274

[a] Gender differences statistically significant at $p < .001$.
[b] Gender differences statistically significant at $p < .05$.

attitudes toward the subject of mathematics and are more likely to enroll in relevant extracurricular activities than are female students. More male than female students report that they look forward to mathematics classes, whereas more female than male students report that they are afraid to ask questions in class. These gender differences are the strongest among Latino students. Among African Americans, there are no gender differences with regard to whether students are afraid to ask questions, and thus African American young women may have less anxiety about mathematics than do their White or Latina counterparts.[6] The majority of eighth graders seem to recognize the importance of mathematics for their future, with small gender differences existing for Whites and African Americans.

Participation in extracurricular activities represents students' exposure to further learning opportunities, but also reveals students' interest in mathematics. Although few students participate in such activities, male students are more likely than are female students to do so. Again, these differences are the strongest among Latinos. It is also important to note that both Latinos and especially African Americans have high levels of extracurricular participation and very positive mathematics attitudes, despite their low levels of achievement in this subject. Since I found that minority students with particularly high levels of extracurricular participation are concentrated in urban areas, it is possible that minority students' high participation in these activities may be explained by their concentration in large, urban schools that may offer a variety of clubs. It is doubtful, though, that in the absence of other instructional programs, extracurricular activities would substantially improve students' achievement.

The positive attitudes of minority students toward mathematics and science have also been noted in earlier studies (Clewell and Anderson 1991; Mickelson 1990). Although most re-

[6] This pattern of gender differences in students' attitudes seems to be specific to mathematics and does not represent students' general attitudes toward school. For example, there are few gender differences among students who are afraid to ask questions in English and social studies; with regard to English, the percentages of male and female students, respectively, who are afraid to ask questions are 14 percent and 15 percent for Whites, 20 percent and 15 percent for African Americans, and 20 percent and 21 percent for Latinos.

searchers have suggested that there is a direct relationship between students' achievement in mathematics and their attitudes or participation in relevant activities, these relationships may not exist for African American or other minority students. Elements of these students' family environments, communities, and schools may be more crucial for the students' underachievement in mathematics than may the students' attitudes toward this subject.

A number of factors may influence students' "choice" (interest in mathematics), which may actually mask differences among male and female students. Socioeconomic status is an important predictor of both mathematics achievement and career decisions, especially for female students (Oakes 1990). Moreover, students' level of achievement and placement in low-ability groups have also been found to have a negative effect on students' social-psychological makeup and attitudes toward academic subjects (Braddock 1990; Gamoran 1987; Oakes 1985). Learning opportunities that give students greater exposure to mathematics may positively affect students' attitudes toward these subjects. Thus, female students' advantages in ability-group placement may positively influence their career choices and attitudes toward mathematics.

The gender differences in the choice of mathematics and science careers are fairly strong among students with similar achievement levels, attitudes toward mathematics, and social background characteristics (see Table 4). Among all three racial-ethnic groups, young women have much lower probabilities of choosing a mathematics- or science-related career than have comparable young men.

Students' gender also affects their attitudes toward mathematics, even when achievement, ability-group placement, and social background are taken into account (see Table 4). Female students are less likely to enjoy their mathematics classes, and White female students are less likely to believe that these classes will be useful for their future than are comparable male students. White female and Latina students also show higher levels of anxiety than do their male counterparts. The effect of gender is somewhat stronger on participation in extracurricular activities. Among all three racial-ethnic groups,

Table 4. Multivariate Analyses for Eighth Graders' Measures of Choice: Gender Coefficients

	White Students	African American Students	Latino Students
Logistic Regression Coefficients[a]	Exp (Beta) (gender)[b]	Exp (Beta) (gender)[b]	Exp (Beta) (gender)[b]
Choice of a math/science career	.35***	.44***	.36***
Participation in mathematics or computer clubs	.65***	.76*	.56**
Average N	12,094	2,367	2,571
Attitudes toward mathematics (OLS unstandardized coefficients)[c]	B(gender)	B(gender)	B(gender)
I look forward to mathematics class[d]	−.09***	−.14*	−.23**
	(.02)	(.06)	(.07)
Afraid to ask questions in mathematics class[d]	.09***	−.03	.13*
	(.02)	(.06)	(.06)
Math will be useful in my future[d]	−.11***	−.10	.06
	(.02)	(.05)	(.06)

* p <.05, ** p <.01, *** p <.001.

[a] Logistic regressions use the following variables as controls: mathematics achievement, socioeconomic status and its interaction with gender, age, mathematics grades since the sixth grade, type of high school curriculum planned, and parents' expectations for attending college.

[b] Contrast category = male.

[c] OLS regressions use the following variables as controls: Mathematics achievement, enrollment in a high mathematics track, mathematics teacher rating of student's behavior, socioeconomic status and its interaction with gender, age, mathematics grades since the sixthg rade, type of high school curriculum planned, parents' expectations for attending college.

[d] Standard errors in parentheses. For these regressions attitudes towards mathematics were not dichotomized, but were kept as ordinal variables with categories ranging from 1 to 4.

young women have much lower probabilities of participating in relevant extracurricular activities than do comparable young men. Except for beliefs about the usefulness of mathematics, gender differences in these variables remain the strongest among Latinos.

Overall, it seems that the patterns of gender differences in middle school students' mathematics achievement, career choices, and attitudes that I found are consistent with those noted in earlier studies. Most of the reports of research on achievement that were published in the late 1970s and early 1980s found significant racial and ethnic differences, but no gender differences in measures of general mathematics performance (Berryman 1983; Educational Testing Service 1989; Lockheed et al. 1985; Oakes 1990). Gender differences appeared only in studies examining specific mathematical skills, such as computation, mathematical applications, and problem solving (Lockheed et al. 1985).

The pattern of gender differences in interest in mathematics and related careers has also remained stable over the past 15 years or so. A few studies published in the late 1970s found that by the ninth grade, boys were much more likely to choose mathematics-related careers than were girls (Berryman 1983). In a longitudinal study of New England middle school students conducted in 1976, the boys reported more positive attitudes toward mathematics and stronger beliefs that mathematics was a useful subject to know than did the girls (Brush 1985). Similar findings were also reported recently in a national study commissioned by the American Association of University Women (AAUW 1992).

If one considers the developmental pathway to mathematics participation, one sees that during the middle grades, gender differences in achievement and learning opportunities are either nonexistent or favor female students. However, gender differences in various indicators of choice provide some clues to the eventual decline in women's participation in mathematics. These findings begin to clarify the nature of the relationships among opportunity, achievement, and choice. As Berryman (1983) tentatively suggested, attitudes toward mathematics and career decisions develop independently of the other two dimensions. Gender differences in attitudes and orientations could affect further learning opportunities during high school, where students are relatively free to choose their own courses.

Patterns for 10th-grade Students

Achievement and learning opportunities. The further development of gender differences during high school is shown by data from the first follow-up of the NELS:88 study. Indicators of mathematics achievement (average test scores and grades) show few gender differences among students in the 10th grade (see Table 5). The small gender differences in the average test scores of African American and Latino students disappear in multivariate analyses controlling for students' background characteristics.[7] Again, in the 10th grade, racial and ethnic differences in achievement and learning opportunities are much stronger than are gender differences.

Male and female students are generally exposed to similar learning opportunities in enrollment in courses, but female students are somewhat advantaged in enrollments in the academic curriculum. In logistic regression analyses that controlled for students' achievement levels, social background, and aspirations, the advantage of female students remained statisti-

[7] The initial gender differences in mathematics achievement may be due to students dropping out of school, which is correlated with social background. Although among African Americans, the drop-out rate of males (12.7 percent) is only 1.5 percent higher than that of females (11.3 percent), the male dropouts had much lower average achievement levels than did the female dropouts (mean achievement score of 38.6 versus 41.7). Among Latino students, although no strong gender differences exist in the average achievement of dropouts, females drop out at a higher rate than do males (14 percent versus 9 percent). Because information on achievement was available only for 187 African Americans and 154 Latinos who dropped out of the original public school sample, these subsamples were too small to permit further analyses.

Table 5. 10th-grade Mathematics Achievement and Learning Opportunities, by Gender and Race-Ethnicity

	White Students		African American Students		Latino Students	
	Male	Female	Male	Female	Male	Female
Mathematics Test Scores						
$\bar{X}$	51.75	51.61	43.22	44.71[a]	46.28	44.64[a]
(s)	(9.85)	(9.61)	(7.82)	(8.72)	(8.73)	(7.92)
Mathematics Grades Since the Ninth Grade						
$\bar{X}$	4.89	4.74[a]	4.65	4.77	4.44	4.60
(s)	(1.97)	(1.99)	(1.83)	(1.80)	(1.74)	(1.84)
Curriculum and Course Work Enrollment (percentage enrolled)						
Academic curriculum	32.1	35.5[a]	20.8	31.0[a]	22.5	25.5
Algebra I	68.7	69.6[a]	60.9	62.6	65.9	68.9
Geometry	48.8	51.0[b]	36.1	44.4[a]	37.7	35.9
Algebra II	27.5	27.0	20.1	21.0	25.5	23.3
Average *N*	4,504	4,546	807	851	635	651

[a] Gender differences statistically significant at $p < .01$.
[b] Gender differences statistically significant at $p < .05$.

cally significant only among White students (odds of 1/1.16, $p < .01$).[8]

Although historically a similar proportion of males and females enrolled in the academic curriculum (NSF 1988), Gamoran and Mare (1989) found that among the 1980 high school sophomores, females had a 4 percent higher chance of enrolling in the academic curriculum than had males. These authors suggested that changes in cultural expectations about gender roles may have eliminated gender biases in track placements. The advantage of White females in enrollment in the academic curriculum has important implications because enrollment in such programs ensures a greater exposure to both basic and advanced mathematics courses (NSF 1988; Oakes 1990).

Choice. Tenth-grade measures of mathematics choice and attitudes, however, indicate that greater gender differences in mathematics participation may indeed appear, once students complete their mathematics course requirements (see Table 6).

High school students are likely to continue to take required courses in mathematics up to the 10th grade. Although more than half the respondents reported taking such courses because they were required to do so, a higher percentage of females than of males did so. Again, the differences were the weakest among African Americans and the strongest among Latinos. Almost 70 percent of the Latina students said that they took mathematics because they were required to do so. The White male students seemed to have the greatest interest in this subject, since one-third of them reported choosing to enroll in mathematics.

Female students tended to have less confidence in their mathematics performance than did their male classmates. These differences were especially strong among Latinos; young Latinas responded more negatively than did any other group of students, especially to the statements indicating whether mathematics was one of their best subjects and whether they had always done well in mathematics. Fewer gender differences were found among African Americans, with the exception of students' estima-

[8] The odds of male to female enrollment in an academic curriculum are 1/1.26 for African Americans and 1/1.25 for Latinos. The following variables were included as controls: 10th-grade mathematics achievement, mathematics grades since the sixth grade, age, socioeconomic status and its interaction with gender, amount of mathematics homework, parents' expectations for college, and type of high school curriculum planned in the eighth grade.

Table 6. 10th Graders' Measures of Choice, by Gender and Race-Ethnicity

Measure of Choice	White Students		African American Students		Latino Students	
	Male	Female	Male	Female	Male	Female
Reasons for Taking Mathematics[a]						
Not taking math	3.1	2.5	2.0	1.0	3.2	2.4
Required	55.9	60.6	61.3	63.1	56.4	69.5
My choice	33.1	28.9	26.1	26.7	23.3	18.6
Recommended or assigned	8.0	8.0	10.5	9.2	17.1	9.6
Judgments of Mathematics Performance and Effort (percentage who agree)						
Math is one of my best subjects.	64.5	54.2[b]	69.3	62.1[b]	63.7	44.8[b]
I've always done well in math.	68.4	71.2[b]	72.0	69.4	65.5	50.7[b]
I get good grades in math.	70.4	66.7[b]	73.9	71.9	70.3	56.8[b]
I do badly in math tests.	27.2	31.3[b]	26.0	32.9[b]	32.7	33.7
I try hard in math almost daily.	45.6	60.6[b]	52.1	74.6[b]	50.1	64.6[b]
Average *N*	4,610	4,503	782	829	606	648

[a] Chi-squares are statistically significant for Whites and Latinos at $p < .01$.
[b] Gender differences significant at $p < .01$.

tion of their own mathematics effort. Almost 25 percent more African American female students than male students reported that they tried hard almost daily in mathematics. Overall, most female students reported that they tried hard almost daily in mathematics, but they did not judge their mathematics performance to be as high as did the male students.

Racial and ethnic differences are also striking with regard to the students' judgments of their mathematics performance. Despite their low mathematics test scores (shown in Table 5), the minority students, especially the African Americans, had a positive image of their academic performance in this subject. About 70 percent or more of the African American male students reported that mathematics was one of their best subjects and that they had always done well and received good grades in mathematics. These minority students also had positive attitudes toward this subject and participated in relevant extracurricular activities at higher rates than did other students in the eighth grade.

Some gender differences exist among African Americans' self-concept of performance, in a direction similar to that found for Whites and Latinos. The reasons for these gender differences are not entirely clear. A number of factors could influence the formation of these social-psychological characteristics. As the relevant literature suggests, socioeconomic status and associated parental encouragement and aspirations may be important factors, especially for the mathematics self-concept of female students. Other studies have shown that mother's education and socioeconomic background are important predictors of young women's success and persistence in mathematics (Oakes 1990). On the other hand, students' achievement levels, grades, and academic effort would also be important influences on students' judgments of their school performance.

Multivariate analyses can explore whether gender differences in students' judgments of academic performance and effort are influenced by these factors. I combined the original variables into an additive index indicating students' self-concept of mathematics performance. I treated students' reports on how hard they try in this subject as a separate dependent variable because of the strong gender differences in it.

The White female students and Latina students had a lower self-concept of their mathematics performance than did their male counterparts, irrespective of socioeconomic status, achievement, and levels of homework (see Table 7). Once these variables were controlled for, gender differences in mathematics self-concept disappeared among the African American students, although the African American female students remained much more likely than did their male counterparts to report that they tried

Table 7. Multivariate Analyses of 10th Graders' Measures of Choice: Gender Coefficients

OLS Unstandardized Coefficients[a]	B(gender)	B(gender)	B(gender)
Self-concept of mathematics performance[b]	−.20***	−.05	−.41***
	(.02)	(.07)	(.09)
Tries hard almost every day in mathemnatics[b]	.13***	.22**[b]	.09**
	(.01)	(.03)	(.04)

[a] Standard errors in parentheses; male = 0, female = 1.
[b] The following variables are included in the regressions as controls: Tenth-grade mathematics achievement, socioeconomic status and its interaction with gender, age, mathematics grades from the sixth to the ninth grade, amount of mathematics homework, parents' expectations for attending college.
** $p < .01$, *** $p < .001$.

hard in mathematics. This gender effect was present for the other two groups and remained strong even when the amount of time spent on homework was controlled for. That is, despite the similar levels of achievement and effort (as indicated by the amount of time spent on mathematics homework), all the female students believed more strongly than did the male students that they tried hard in mathematics courses. The White female and Latina students also judged their mathematics performance to be lower than did the male students. Thus, it is probable that fewer female students than male students would choose advanced mathematics courses as electives.

In earlier cohorts of high school seniors, fewer female than male students enrolled in advanced courses, such as Trigonometry, Precalculus, and Calculus (Armstrong 1985; Miller 1991). At the time of this study, NELS:88 data were not available for 1992, when this cohort of students reached their senior year. However, data from the National Assessment of Educational Progress indicated that there were significant gender differences, especially for the White high school seniors of 1992, in average levels of achievement. Similar differences also existed in the proportion of students who reached advanced levels of mathematics achievement (Mullis, Dossey, Owen, and Phillips 1993).

Overall, gender and racial-ethnic interactions regarding students' mathematics-related attitudes and educational experiences are important. The factors leading to the underrepresentation of students in advanced mathematics courses and related careers may actually differ according to students' gender and race-ethnicity. Latinas tend to be the most disadvantaged group, since they face barriers in all three domains: opportunity, achievement, and choice. For African American students, both female and male, the barrier to mathematics participation may prove to be their limited exposure to learning opportunities and their low levels of mathematics achievement. Attitudes and early career choices may be the major barrier for the mathematics participation of White female students, who have equal levels of achievement with White male students and are exposed to greater learning opportunities from the middle grades to the early years of high school.

CONCLUSION

I return to my initial premise that an intensive understanding of equity in mathematics requires caution in applying general findings for gender to any one race or ethnic group. The analyses reported in this article, though, indicate that some similar patterns of gender differences in opportunity, achievement, and choice exist for all three groups. Up to the early years of high school, female students of White, African American, and Latino backgrounds do not lag behind their male classmates in mathematics achievement and are actually advantaged in learning opportunities in mathematics. However, this gender equity, or even female advantage, may be due *not* to young women's interest in mathematics but, rather, to school placements and course requirements. Young women of all three groups may be reluctant participants in mathematics learning. Gender differences in the decision to pursue a mathematics-related career and in attitudes toward mathematics are already apparent in the eighth grade. Strong gender differences in students' judgments of their mathematics performance also exist in the early years of high school. These gender differences may lead to a decline in women's mathematics participation later in school, when enrollment in such courses is optional.

Of key importance is the finding that students' attitudes toward and self-confidence in mathematics vary greatly by gender, as well as by race and ethnicity. Although Latinos and African Americans have relatively low levels of achievement and limited exposure to learning opportunities, their attitudes toward mathematics are positive. This attitude-achievement paradox has also been noted by other researchers (Clewell and Anderson 1991; Mickelson 1990), but the reasons for its existence are not clear. Mickelson provided a theoretical explanation by introducing the distinction between abstract and concrete attitudes toward education: Whereas African Americans' abstract attitudes reflect the dominant achievement ideology, their concrete attitudes are more pessimistic and reflect the limited returns of education for minority groups. In her study, she measured the concrete attitudes of African American students, which reflected their estimation of the probable returns of education for themselves, as opposed to abstract beliefs about the value of education. The concrete attitudes of these students were close to their levels of achievement. This distinction does not explain the attitude-achievement paradox found in my study, however. African American students and, to a lesser extent, Latino students responded positively to statements about the importance of mathematics for their own future and their own mathematics performance, despite their low test scores in this subject. At this point, I can only speculate that minority students may judge their performance on the basis of their reported grades, which seem to be relatively high, as well as on other positive messages that they may receive within their school environments.

Gender differences in mathematics attitudes not only vary by race and ethnicity, but are strongest among Latino students. Along with limited learning opportunities and low levels of achievement, Latinas seem to be the students with the most negative attitudes toward mathematics and toward their own academic ability in this subject. Gender differences in the Latino population seem to follow traditional patterns that may no longer exist among White or African American populations. Although little is known about the educational experiences of Latinas, researchers have noted that within many Latino cultures, traditional gender roles and orientations tend to persist (Acosta-Belén 1986; Bose 1986). Latinas in the United States also tend to have relatively low levels of education and to work in blue-collar and service occupations that are segregated by gender (Bose 1986; Pessar 1987). Thus, both the culture and the job-opportunity structure that many Latinas face may not provide opportunities that encourage young Latinas to aspire to nontraditional gender roles and occupations.

There is some research evidence that the school experiences of Latinas may also place them at a disadvantage. Studies of Mexican American children indicate that girls may have greater difficulty than boys adjusting to the achievement-oriented and competitive environment of schools. However, it is encouraging to note that these girls are also quite responsive to positive interventions, such as bilingual and bicultural programs, that tend to enhance their self-concept significantly (Nieto Senour 1977).

The opportunity structures available to women and men from different social backgrounds, as well as ethnic-specific gender roles, seem to interact in their influence on students' interest in and performance of mathematics. Racial and ethnic differences in cultural, economic, and educational factors may actually translate into differences in opportunity, achievement, and choice.

In sum, the findings presented here have elucidated the interrelationships and relative importance of the three conceptual domains of opportunity, achievement, and choice for equity in mathematics participation. It is possible that different gender and racial-ethnic groups are at different stages of development in terms of equity in mathematics achievement and participation. For male and female minority students, learning opportunities and levels of achievement are the most important barriers to mathematics participation. Their relatively high interest in mathematics could provide educators with an important opportunity to engage these students in more intensive academic efforts. Latinas seem to be the most disadvantaged group, since they are faced with additional limitations in attitudes toward mathematics and toward their own academic abilities.

White women are the most advantaged of the three groups of women considered in this article, and many have overcome the formal barriers that opportunity and achievement represent. In terms of opportunity, they may often be even more advantaged than their White male classmates (as in the case of eighth-grade ability-group placement and 10th-grade academic curriculum enrollment). For them, it is attitudes toward mathematics and career choices that may undermine their future participation in mathematics-related fields.

The findings regarding White women show that increased opportunities to learn, such as placement in high-ability tracks, may indeed eliminate the gender gap in mathematics achievement, especially when enhanced opportunities are coupled with a common core curriculum, such as the one usually found in the middle grades. However, although educational opportunities and high achievement may provide the necessary conditions for mathematics participation, early career choices and attitudes toward these fields may become equally important during the last years of high school and beyond. These career decisions and attitudes seem to develop independently of students' learning opportunities and achievement levels and may cast the deciding vote on whether White women pursue further study in mathematics. All three parts of the equation—opportunities, achievement, and choice—are important for gaining gender equity in mathematics, although the influence of each one may be manifested at different stages of schooling and may vary by race-ethnicity. The "path to math," as Oakes suggested, is a conditional relationship between mathematics choices and participation, one that becomes important only when students have high levels of achievement and ample opportunities to learn.

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