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AUTHOR	Finn, Jeremy D.; Gerber, Susan B.; Wang, Margaret C.
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ABSTRACT

This study investigated high school policies and practices that encourage or discourage students' enrollment in advanced mathematics courses, examining the effects of schools' graduation requirements, course offerings, and tracking practices on patterns of mathematics courses taken by high school students. Data came from the High School Transcript Study and the 1994 National Assessment of Educational Progress. Data were collected on over 25,000 high school students from 340 schools nationwide. Results indicated that larger schools offered more advanced mathematics courses, while mathematics course offerings in small, rural schools (both high- and low-poverty rural schools) were substantially below those of schools in other settings. There were no systematic differences between high- and low-poverty schools in number of advanced courses offered or proportion of advanced courses. School polices and practices affected students' course taking differentially within schools. Graduation requirements affected the number of courses students took and had a stronger impact on students in vocational tracks. Course taking in mathematics did not relate to school enrollment. There was a significant association of course taking with school poverty level. All measures of course taking showed large, significant differences among tracks. (Contains 54 references.) (SM)

Taking Mathematics in High School:

Is Opportunity Equal?

Jeremy D. Finn, Susan B. Gerber,
and
Margaret C. Wang

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INTRODUCTION

The purpose of this study was to investigate policies and practices of high schools that encourage or discourage students' enrollment in advanced mathematics courses.[1] In particular, we examined the effects of schools' graduate requirements, course offerings, and tracking practices on the patterns of mathematics courses taken by high school students. Throughout the study, special attention was given to minority students and students in schools serving low-income populations. The primary objective was to identify a set of alterable school practices that can be implemented to increase access to learning opportunities among all students and among students at risk in particular.

Why Is Course Taking Important?

This study was based on two premises: that engagement in advanced courses is an important outcome, worthy of study in its own right, and that mathematics courses in particular provide keys to postsecondary schooling and improved employment opportunities. These are not difficult assumptions to make. Educators have long recognized that course taking opens the doors to learning and to further education-dependent experiences. In 1983, the National Commission on Excellence in Education released *A Nation at Risk*, laying the blame for students' academic deficiencies squarely on course-taking patterns—curricula composed of an overabundance of survey courses and few with challenging content. The Commission recommended that schools around the nation increase their graduation requirements to include 4 years of English, 3 years of science and social studies, one-half year of computers, and 3 years of mathematics for all high school graduates. Following publication of the Commission's report, many states, districts, and schools revised their requirements to conform to part or all of these specifications (Blank & Engler, 1992; Clune & White, 1992). Currently, 20 states require at least 3 years of mathematics for all high school graduates (CCSSO, 1998); other states leave the decision to local school boards.

[1] The work reported here was performed under a grant from the National Center for Education Statistics (NCES) for the Secondary Analysis of National Assessment of Educational Progress (NAEP) data. Portions of this paper were presented at the annual meeting of the American Educational Research Association in New Orleans, May 2, 2000.

It is not presumed that enrolling in particular mathematics courses ensures that the material will be learned; this depends on such obvious factors as content coverage, quality of instruction, and the student's engagement in learning. On the other hand, without enrolling in particular courses, the likelihood that the material will be learned approaches zero. Access to course content is the key to learning.

The link between course taking and academic achievement has been demonstrated repeatedly. With data from a nationwide sample of students, the National Educational Longitudinal Study of 1988 (NELS:88) showed that "Test score increases from the end of 8th grade to the end of grade 12 are strongly related to the number of math and science courses students complete in high school" (Hoffer, Rasinski, & Moore, 1995). Multivariate studies indicate that this association is attributable to the amount of course work taken even after student characteristics (e.g., socioeconomic status, aptitude, prior achievement) are controlled statistically (Epstein & MacIver, 1992; Gamoran & Hannigan, 1997; Jones, Davenport, Bryson, Bekhuis, & Zwick, 1986; Lee, Croninger, & Smith, 1997; Peng, Owings, & Fetters, 1982; Rock & Pollack, 1995; Sebring, 1987; Welch, Anderson, & Harris, 1982). Jones (1987) demonstrated that the relationship of mathematics performance with number of courses taken "is essentially the same for black males, black females, white males, and white females" (p. 186), a finding supported by Rock and Pollack (1995).

The extent of *advanced* course work may be more important than just the total amount of course work. Analyzing data from the National Assessment of Educational Progress (NAEP), Williams, Atash, & Chaney (1995) found stronger relationships between achievement in mathematics and courses taken beyond the basic requirements. For example, Lee et al. (1997) found that particular mathematics courses—those classified as "academic"—are strongly related to mathematics performance. The authors conclude that there are advantages to a constrained curriculum of academic courses, in contrast to a school's offering a broad spectrum of less challenging course work.

Why Is Mathematics Particularly Important?

This investigation focused on mathematics because of its key role in providing access to further education and postschooling experiences. This relationship was recognized by Oakes (1990), who concluded that some courses are especially important because they serve as gatekeepers. Grade-8 algebra and high school calculus were cited as prime examples; the latter "is a prerequisite for entry in most science-, mathematics-, and technology-related majors at college" (p. 37). With NELS:88 data, Schneider, Swanson, and Riegle-Crumb (1998) demonstrated that "students in higher mathematics and science sequences...are more likely to graduate from high school and attend college" (p. 25).

The importance of mathematics was highlighted in a White Paper prepared for U.S. Department of Education Secretary Richard Riley (U.S. Department of Education, 1997). Based on data from many sources, the Paper concluded:

> In the United States today, mastering mathematics has become more important than ever. Students with a strong grasp of mathematics have an advantage in academics and in the job market (p. 5).... Students who take rigorous mathematics and science courses are much more likely to go to college than those who do not (p. 9).... Algebra is the 'gateway' to advanced mathematics and science in high school, yet most students do not take it in middle school (p. 5).... Students of all income levels who take rigorous mathematics and science courses in high school are more likely to go to college, and among low-income students (students in the bottom third of the income distribution), the difference is particularly dramatic (pp. 9–10).... Mathematics achievement depends on the courses a student takes, not the type of school the student attends (p. 6).

Conceptual Framework for the Investigation

Our complete model of course taking is:

Course taking = f(school policies);

Course taking = f(policy interpretation);

Course taking = f(personal choice). [2]

School policies create the context within which students enroll in particular courses. The policy of requiring a particular number of semesters of mathematics for graduation provides a baseline for all students. Other policies, interpreted for individual students by administrators, counselors, and teachers, leave more or less leeway for personal choice. A school may offer an array of beginning and advanced mathematics classes; particular students may be advised to take advanced courses or else to enroll only in basic course work or students may be counseled into academic or vocational tracks.

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[2] The letter "f" stands for "is a function of" or "is attributable to."

Ultimately, personal dynamics mediate students' choices, and the sources of influence are numerous. Researchers have weighed the effects of parents and peers as well as school staff on students' course-taking decisions (e.g., Chen, 1997; Galotti & Mark, 1994; Lantz & Smith, 1981; Leitman, Binns, & Unni, 1995; McCormick, 1995; Rosenbaum, Miller, & Krei, 1996; Spade, Columba, & Vanfossen, 1997). Others have examined the roles of students' attitudes toward mathematics including perceptions of their ability to succeed in particular courses (Catsambis, 1994; Ma & Willms, 1999; Riesz, McNabb, Stephen, & Ziomek, 1994; Updegraff, Eccles, Barber, & O'Brien, 1996; Wilson, Stocking, & Goldstein, 1994). Still others have examined the role of students' postsecondary plans and goals: For those whose future goals are crystallized, the utility of particular courses for obtaining a particular job or for entering a particular college major may be the single most important determinant; for those who are not college bound or students without clear aspirations, going along with friends or the perceptions that a course may be difficult may hold particular sway (Gaskell, 1984; Meece, Parsons, Kaczala, Goff, & Futterman, 1982; Powell & Luzzo, 1998).

This investigation focused on school policies and practices. The specific objectives were: (a) to identify the patterns of mathematics courses taken by American high school students and to examine the correlates of these patterns; (b) to identify school characteristics that are related to practices that affect course taking—that is, course offerings, graduation requirements, and academic tracking; and (c) to study the impact of offerings, requirements, and tracking on course taking in mathematics with particular attention to minority students attending high-poverty schools.

Course Offerings

The configuration of courses available in a school delimits the courses students can take and thus what students learn; that is, "students partake in the curriculum of a school to the extent that it is available" (Lee et al., 1997, p. 100). Both the breadth and depth of course offerings are important. Studies of breadth have focused on total course taking as an indicator of quantity of schooling in a subject area (e.g., Schmidt, 1983; Sebring, 1987).

The curriculum, however, can be composed largely of basic or survey courses or else can include a substantial number of advanced courses. The Third International Mathematics and Science Study (TIMSS) concluded that, on the whole, American curricula in these fields cover more topics but are less intensive than those in other countries. The authors described the typical American curriculum as "a mile wide and an inch deep" (Schmidt, McKnight, & Raizen, 1996, p. 34). The opportunity to take advanced course work has been found to be related to school achievement, even when characteristics of the students (e.g., ability, prior achievement, socioeconomic status (SES), race/ethnicity) are controlled statistically (Epstein & MacIver, 1992; Oakes, 1990; Sebring, 1987). Lee et al. (1997) assessed the extent to which schools' mathematics curricula were composed of academic courses on the premise that if a school's courses are "largely academic in nature, it is no surprise that these are the kinds of courses students take" (p. 2). Using data from NAEP, the authors confirmed that mathematics performance is superior in schools with a "constrained academic curriculum" even when demographic characteristics and the academic makeup of the student population is taken into account.

Despite their importance, advanced courses may not be equally available in all schools or to all groups of students. The report *Multiplying Inequities* (Oakes, 1990) focused on the racial/ethnic and socioeconomic composition of schools. Data consisted of responses to a survey of approximately 6,000 science and mathematics teachers in 1,200 public and private schools. The first analysis focused on the total number of sections of science and mathematics offered per pupil. In middle and junior high schools, fewer sections were available in schools serving low-income populations and in schools with high minority enrollments. The second analysis focused on advanced courses. The results were strong and consistent: "As the proportion of low-income and minority students at a school increases, the relative proportion of college-preparatory and advanced course sections decreases" (p. 35). Calculus, a gatekeeper course, lies at the extreme. The number of sections per pupil in high-wealth schools was approximately four times that of high-poverty schools, even after eliminating over 50% of high-poverty schools that offered no calculus courses at all.[3] Spade et al. drew similar conclusions (1997) in an intensive study of course taking in six high schools.

School size has been shown to mediate course offerings, although the results of prior research are not highly consistent (e.g., Monk & Haller, 1993; Schmidt, 1983). Larger schools may have the resources and

[3] Estimated from Figures 3.8 and 3.9.

teaching staff needed to offer a greater array of courses in a given subject area; however, large inner-city schools may decide that advanced courses are not needed on a regular basis. The present investigation included school enrollment as a potential mediating variable.

Graduation Requirements

A school's graduation requirements are associated with course taking generally. In the years pursuant to publication of *A Nation at Risk*, states' and districts' increased requirements were followed by increased course taking in most academic subjects (Blank & Engler, 1992; Clune & White, 1992). However, increased requirements seem to benefit less able students in particular. Williams et al. (1995) used NAEP data to identify schools whose requirements in each subject were high relative to state requirements and those that were low. More courses were taken, on average, in high-requirement schools. However, the relationship between student ability and course taking was attenuated in high-requirement schools; more low-ability students enrolled in science and mathematics courses in these schools.

Increased requirements tend to affect introductory courses more than advanced courses. In a study of changes in the years following publication of *A Nation at Risk*, Blank and Engler (1992) found that the rates of increase for advanced science and mathematics courses were not as dramatic as those for basic courses. Clune and White (1992) found that courses such as pre-algebra, algebra 1, basic geometry, and computer literacy were the "big gainers." The authors concluded, "these trends show schools becoming distinctly more academic without reaching the higher levels of a college preparatory curriculum" (p. 13). Using 1990 NAEP data, Chaney, Burgdorf, and Atash (1997) found that, for many students, increased requirements affected the quantity of mathematics and science courses taken but not the level; that is, students often take additional course work at an introductory level. In sum, graduation requirements may affect the engagement of high school students in course work generally, and encourage low-ability students to take basic academic course work.

Academic Tracking

No practice distinguishes the courses available to groups of students as definitively as the creation of academic tracks. Tracking, the assignment of students to a group that will be exposed to a particular curriculum was described in 1985 as "so much a part of how instruction is organized in secondary schools ... that we seldom question it. We assume that it is best for students" (Oakes, p. 6). Tracking is a convenient way to organize instruction for students of diverse abilities and is consistent with the widely held belief that "students learn better when they are grouped with other students who are considered to be like them academically" (Oakes, 1985, p. 5). Schools use different terms for their tracks, and some record the student's track in his or her school file while others do not; the most common groupings are college and noncollege tracks or else academic, general, and vocational tracks.

It is no surprise that minority students and students from low-income homes are placed in advanced tracks far less often than are White students or those from higher income homes (Garet & DeLany, 1988; Oakes, 1985, 1990). An extensive study of the distribution of learning opportunities in 1,200 schools discovered this pattern both between and within schools. Since low-income and minority students are concentrated in less advantaged schools and in nonacademic tracks within those schools, the authors concluded that African American and Hispanic minorities face not one but two potential barriers to participation in advanced course work.

Differences in curricula among tracks are pronounced. Students in higher tracks are exposed to more content, to more advanced content, and to more challenging content than are students in lower tracks (Oakes, 1990; Sebring, 1987; Williams et al., 1995). Students in lower tracks are denied access to this material by being locked into a system that makes mobility all but impossible. School policies rarely allow for a reassessment of students' interests and capabilities, especially in the upper grades. And students are locked in by the content of low-track classes. The topics taught in low-track classes are likely to be useful to all students, but the topics not taught "constitute prerequisite knowledge and skills for access to classes in different, and higher, track levels" (Oakes, 1985, p. 78). On tests administered nationally, students in academic tracks outperform students in general tracks, who in turn outperform students in vocational tracks (e.g., Natriello, Pallas, & Alexander, 1989).

Research of the 1990s has engendered continuing debate over the pros and cons of tracking. In an essay published in 1994, Hallinan summarized the commonly held beliefs about the effects of tracking: "The quantity and quality of instruction increases with the level of the track.... Students in high-ability tracks learn more and at a faster pace than do those in lower-ability tracks...Tracking provides no advantage over heterogeneous grouping with respect to the achievement of student in the middle-ability range" (p. 80). All of these factors heap disadvantage on students in lower tracks.

In this investigation, we asked whether the extent of student tracking is related to schools' demographic characteristics and whether the assignment to tracks is related to student gender, race/ethnicity, or socioeconomic status (SES). Although tracking is conspicuously related to the courses students take, we asked whether the effects of tracking differed systematically by student or school characteristics.

Research Questions

The present investigation used data from a nationwide sample of high school graduates to address questions about the effects of school practices and policies on students' course taking in mathematics. In particular, we asked:

(1) Does the extent of offerings in a school affect students' mathematics course taking in total? Do offerings affect course taking in basic or advanced course work? Do offerings affect course taking to a greater extent in high-poverty schools or in low-poverty schools? Do offerings affect course taking to a greater extent among minority or nonminority students?

(2) Does the number of years of mathematics required for graduation influence students' mathematics course taking in total? Do requirements affect basic and/or advanced course work? Do requirements affect course taking differentially in high-poverty and low-poverty schools or among minority or nonminority students?

(3) Do requirements and offerings have differential impact on course taking by students in higher and lower tracks?

To provide a backdrop for answering these questions, we identified distinct course-taking patterns among high school students and examined the relationship of course taking with student and family characteristics; we also documented the types of schools with limited or extensive offerings and the types of schools with higher or lower graduation requirements.

METHODS

Data Source

Data for this investigation were drawn from two sources. The majority of the information came from the High School Transcript Study (HSTS), conducted in conjunction with the 1994 NAEP. During the Summer and Fall of 1994, transcript data were collected for over 25,000 high school students from 305 public and 35 private schools throughout the country. The schools comprised a nationally representative sample of American high schools. Within schools, students were selected to be representative of all graduating seniors.

Data from the HSTS were contained in several files. The School File contained demographic characteristics of the schools including location, enrollment, and graduation requirements. The Student File listed basic demographic information on students such as gender, race/ethnicity, track, and grade point average (GPA). The Course Offerings File contained, for each school, the name of every course offered to students between Grades 9 and 12. Additional information in this file included the major topic area of the course (e.g., algebra) and, when relevant, the level of the course (first or continuing course in a sequence; remedial; honors). The Courses File was a listing of all courses taken by each student participating in the HSTS. The file also included information on the grade level in which the student took the course, the number of credits earned for the course, and the grade earned in the course.

The remaining data were obtained from the 1994 NAEP assessment of students' academic progress. Over three fourths of the students participating in the HSTS took part in the semiannual (now annual) NAEP achievement assessment. As part of this assessment, students completed background questionnaires that included information on family SES and mobility, home literacy items, parents' education levels, and students' postsecondary plans.

Samples for the Current Study

The HSTS employed a multistage sampling plan. In the first stage, geographic areas (primary sampling areas, or PSUs) were selected. Then, several schools within each PSU were selected. Finally, up to 200 students were sampled at random from each participating school. In both the HSTS and NAEP studies, schools with a high percentage of African American and Hispanic students were over sampled to increase the reliability of statistics computed for these subgroups. School- and student-level sampling weights were developed to account for the sampling method and for the small number of nonrespondent schools and students. In addition, a Linked Weights File contained alternative sampling weights designed specifically for analyses involving the merged HSTS-NAEP assessment data. The appropriate sampling weights were employed for all analyses in this study to make the sample more representative of the population of U.S. high schools and graduating seniors.

The present investigation considered only students who graduated from public schools. This eliminated individuals attending the 35 private schools included in the sample. Students from the remaining 305 schools were eligible for inclusion in the analyses. Additional data screening eliminated individuals who (a) were missing a code indicating they graduated from high school, (b) had a sampling weight of zero, (c) did not take any mathematics courses during high school, or (d) were in special education programs. Complete information was available for 22,127 students from the HSTS file. Because not all of the individuals included in the HSTS study took part in the NAEP achievement assessment, fewer students and schools were available for analyses using information such as student SES and postsecondary plans. This subsample included 16,229 students from 246 schools.

Measures

Data for both schools and students were used in this study. School information was obtained from the HSTS files. Student information was derived from the HSTS and the NAEP academic assessment files.

Schools

Both demographic and course-related information on schools were employed. Background information included urbanicity of the school, enrollment, and indicators of the SES of the student population. The urbanicity classifications used in the HSTS were big city (urbanized areas with a population greater than 200,000), urban fringe (outside the city limits but within the urbanized area of a big city), medium city (within the city limits, population between 25,000 and 200,000), and small/rural place (open town or country, population less than 25,000). For this study, the medium city and urban fringe categories were collapsed and referred to as suburban/urban. In the sample, 19% of the schools were from big cities, 46% were rural, and 35% were suburban/urban areas.[4]

The total student enrollment was available for each school. For some analyses, schools were classified as small/medium (40–1,423 students) or large (1,424–3,086 students), in order to study the policies and practices of schools that are particularly large. Approximately 29% of the schools were classified as large.

Two measures of the SES of the student population served by the schools were gathered as part of the HSTS: the percentage of students in the school receiving free lunches and the percentage of students receiving support under Title I. The free lunch indicator was recorded by HSTS in four levels: 0–10%, 11–25%, 26–50%, and 51–100%. The Title I indicator was grouped into three levels: 0–10%, 11–25%, and 26–100%. Initially, 55 schools were missing Title I information; the missing values were imputed. To do so, the relationships among urbanicity, percentage of students receiving free lunch, and percentage of students receiving Title I funds were examined in schools with complete data. Conventions were developed based on these associations, and Title I classifications were assigned to schools missing this information. The poverty status of a school was determined by combining the free-lunch and Title I information. High-poverty schools were defined as those with over 25% of students receiving free lunches and over 10% of students eligible for Title I support. Eighty-nine (29.2%) of the 305 schools were classified as high poverty.

The course-related information available from the HSTS included measures related to quantity and level of mathematics course offerings, mathematics graduation requirements, and school tracking practices. Quantity of offerings was assessed by the number of advanced mathematics areas, out of six, in which courses were offered and the number of distinct semesters of calculus offered. The six content areas considered advanced were second-semester courses in algebra 2 and more advanced algebra, second-semester courses in geometry and more advanced geometry, calculus, trigonometry, probability/statistics, and advanced

[4] Unless otherwise noted, frequencies and proportions reported in the Measures section of this paper are based on raw, unweighted data. They are based on the actual number of students and schools sampled.

computers. Schools offered zero, one, or two semesters of calculus. The level of course offerings was assessed by the ratio of the total number of advanced to basic courses (not areas) offered. Finally, the number of semesters of mathematics required for graduation, out of eight, was recorded for each school.

Unfortunately, information regarding tracking policies of schools was not available. As a proxy for school tracking practices, the proportion of students in the vocational track was estimated for each school by aggregating student information.

Students

Three types of student information were employed in this study: personal and family characteristics, school outcomes, and high school track and course-taking measures. Background characteristics available from the HSTS data included gender and race/ethnicity. Sixty-five percent of the sample consisted of non-Hispanic White students, 18% of African-American students, 12% of the sample were students of Hispanic decent, and 6% were Asian students. A total of 237 Native American students and students of other ethnic origins were eliminated from analyses that included the race/ethnicity variable.

Participation in the free-lunch program was recorded for the subset of students completing the NAEP background questionnaire. Slightly over 18% of students in the subsample received free lunches. The questionnaire also solicited the parents' level of education, pressure for literacy in the home, and student mobility. Parental education was coded to represent the highest level of education attained by the student's mother or father. The categories were high school graduate or less (31%), some college education (26%), and college graduate (43%). The home literacy measure was a composite derived from four yes/no questionnaire items. The items assessed whether the student's home had (a) more than 25 books, (b) an encyclopedia, (c) magazines, and (d) the daily newspaper. The mobility measures pertained to the number of times the student changed schools in the prior two years: none (87%), one (8%), two or more (5%).

An additional item on the NAEP questionnaire assessed students' postsecondary plans. Categories of response included nonacademic plans (work full time, join the military; 12% of students in the merged subsample), plans to attend a vocational or 2-year college (26%), and plans to attend a 4-year college (59%).

Information regarding student track was available from both the NAEP assessment and HSTS sources, although in slightly different forms. In the HSTS data, track was delineated as vocational, academic, both, or neither. The categories of the NAEP student questionnaire were general, academic, vocational, or other. The cross tabulations of these variables were examined for patterns and used to create one tracking variable with three categories: vocational (7% of students), general (33%), and academic (60%).

The HSTS also provided complete transcript information on all students. Each course taken in high school is listed as well as the number of Carnegie Units, or credits, associated with the class. One Carnegie Unit represents a course that meets once per day, five days per week, for the entire school year. Courses of other duration are assigned a proportional number of Carnegie Units.

For the present study, each of the 79 distinct mathematics courses available to students was assigned to one of five levels, using a refinement of the classification scheme of Rock and Pollack (1995). The final classifications were[5]:

Level 1: Basic mathematics, pre-algebra, and introduction to computers.
Level 2: Algebra 1 and other courses involving beginning algebra.
Level 3: Algebra 2, introductory geometry, and courses involving algebra 2 topics.
Level 4: Algebra 3, advanced geometry, and other advanced courses exclusive of calculus.
Level 5: Calculus and analytic geometry.

This information was used to derive a series of course-taking measures: (a) the number of years that mathematics was taken between Grade 9 and Grade 12; (b) the total number of Carnegie Units of mathematics taken (this was rounded to the nearest one half, which roughly equates to semesters of coursework); (c) the highest level of course taken, out of five; (d) the proportion of Carnegie Units earned at level 1, the proportion of Carnegie Units earned at level 4 or level 5, and the ratio of Carnegie Units earned in advanced courses (level 3 and above) to basic courses (levels 1 and 2); and (e) the student's GPA in mathematics.

In addition, a mathematics course-taking classification was identified for each student. On the basis of course-taking patterns, students were placed in one of four categories: remedial, slow starter, modal, or advanced. Several aspects of course taking were examined to determine the classifications: the numbers of

[5] The actual course titles in each level are given in Appendix A.

courses taken, the concentration or variability in course levels, the sequencing of course levels (e.g., steady progression from basic to advanced courses, movement between levels throughout the grades), and the sequencing of specific courses (e.g, year in which geometry was taken).

The final classifications were:

Remedial (17.3%)[6] – Students who took several level-1 and/or level-2 courses but did not take any courses at level 3 or higher. In the most common sequences, students took only basic courses, such as consumer mathematics, general mathematics, and pre-algebra. Of the remedial students who got as far as algebra 1 in Grade 10, a number repeated algebra 1 in Grade 11. On average, remedial students enrolled in 5.1 semesters of mathematics course work.

Slow Starters (15.3%) – Students who initially took several courses at level 1 and/or level 2, but who did advance to level-3 courses such as algebra 2 or geometry. The most common sequence for these students was pre-algebra (or general mathematics 1), algebra 1, and geometry (or algebra 2) in Grade 11. Slow starters who took a larger number of courses tended to do so at the basic level. On average, slow starters enrolled in 6.3 semesters of mathematics course work.

Modal (55.0%) – Students who took at least one level-3 course; many took more than one. Some students also enrolled in one or two level-4 courses. Few of these students took any level-1 courses, and those who did enrolled in pre-algebra. None of these students took more than two level-2 courses. The most common sequence was algebra 1, algebra 2, and geometry in Grades 9 through 11 (although the order may differ). Students who took mathematics in Grade 12 usually took an advanced course—for example, pre-calculus, algebra 3, or trigonometry. On average, modal students enrolled in 7.1 semesters of mathematics course work.

Advanced (12.4%) – Students who took one or more calculus courses or alternatively took a series of three or more level-4 courses. None of these students took any level-1 courses, and few took courses at level 2. Theses students often doubled up on mathematics courses in Grade 10 or 11. Most of those who took calculus took an advanced placement (AP) section. On average, advanced students enrolled in 8.7 semesters of mathematics course work.

Data Analysis

The study's three objectives required somewhat different statistical approaches. Descriptive analyses (correlations, means, cross-tabulations) were performed with and without using the sampling weights, although most of the results presented in this report are "weighted." All statistical modeling (ANOVAs, regressions) was conducted using the sampling weights. Prior to the analyses, the sampling weights were normed so that the sum of the weights was equal to the total sample size; this procedure assures that statistical

[6] Weighted percentages.

estimates and tests are based on the correct number of degrees of freedom. A type-I error rate of .01 was used for all tests of significance.

Objective 1 (identify course-taking patterns and examine their association with other variables) required univariate and bivariate descriptive statistics. Measures of course taking were examined in conjunction with student demographics, academic track, postsecondary plans, GPA, and family characteristics (home literacy, mobility, and parents' education).

For objective 2 (school characteristics related to mathematics requirements, offerings, and student tracking), we first computed correlations between the school characteristics as numerical scales (percent free lunch, percent Title I enrollment) and five dependent variables (number of advanced areas of mathematics offered, number of unique calculus courses offered, ratio of advanced to basic courses offered,[7] number of semesters of mathematics required for graduation, percentage of students in a vocational track).

Next, we applied a series of three-factor ANOVAs for unequal *n*s using the Multivariance program (Finn & Bock, 1985), with the dependent variables as outcomes. The independent variables were school enrollment (small/medium or large), urbanicity (large city, rural, or suburban/urban), and poverty status (high or low). The classifications allowed us to focus on particular sets of schools (e.g., schools with very large enrollments) and on particular interactions among school characteristics. Enrollment and urbanicity were viewed primarily as background variables, and were entered into the model as the first and second factors, respectively. Poverty status was the primary independent variable and was tested controlling for enrollment and urbanicity. All two-way and three-way interactions were included in the model. Because urbanicity and poverty status are closely related, an ANOVA was also performed to test urbanicity controlled for poverty status.

[7] The distribution of this variable was highly skewed; the logarithmic transformation was used as the dependent variable in the analysis.

Objective 3 (impact of school requirements, offerings, and student track on course taking) required a series of two-level hierarchical linear model (HLM) analyses; we used the HLM program (Bryk, Raudenbush, & Congdon, 1996). The dependent variables, examined in separate analyses, were: students' years of mathematics taken, total semesters taken, highest level of mathematics taken out of five, proportion of courses taken at level 1, and ratio of advanced-to-basic courses taken.[8]

The student-level independent variables were gender, race/ethnicity, and track. The school-level independent variables were enrollment, urbanicity, poverty status, semesters of mathematics required for graduation, and the ratio of advanced- to basic-level courses offered. The contrasts for race/ethnicity used non-Hispanic White students as the comparison group. Track contrasts compared vocational-track and academic-track students with general-track students, respectively. The urbanicity contrasts used suburban/urban schools as the comparison group.

The complete HLM models are given in Appendix B. The models had fixed slopes; only the intercepts were treated as random. Multivariate likelihood-ratio tests were used to determine significance of main effects and interactions composed of more than one contrast. The analyses were performed in two stages. In the first stage, the models included interactions with student track only (race/ethnicity-by-track, poverty-by-track, course-offerings-by-track, and requirements-by-track). In the second stage, interactions with school poverty and student race/ethnicity (requirements-by-race/ethnicity, offerings-by-race/ethnicity, requirements-by-poverty, offerings-by-poverty) were added. In both stages, when some interactions were found to be nonsignificant, they were omitted from the model and remaining effects were reexamined. Effect sizes were estimated from the final reduced models.

[8] The distribution of this variable was highly skewed; the logarithmic transformation was used as the variable in the analysis.

RESULTS

Objective 1: Patterns of Mathematics Courses Taken by American High School Graduates

Overall frequency distributions of the primary course-taking measures are given in Appendix C. Approximately 19% of high school graduates take fewer than six semesters of mathematics, with about 13% taking four semesters or fewer. On the other side of the equation, about 81% of high school graduates take at least six semesters of mathematics as recommended by the Carnegie Commission. Whether this is due to state and school requirements, and whether the courses are composed of basic or more challenging material, are questions yet to be answered. Approximately 12% of high school graduates accrue more than six semesters of mathematics credit. Similar results are reflected in the number of years, out of 4, in which students enroll in mathematics courses. Approximately two thirds of high school graduates have taken mathematics for 3 years or more.

The percentages for the highest course taken are not as encouraging. Approximately 60% of high school graduates have stopped their mathematics course work at level 3 or below; that is, they have taken no course work whatsoever that would be classified as advanced. The highest-level course taken by the majority of students is a second-level algebra course or introductory geometry. Another 29% of students have taken at least one advanced course – algebra 3 or other advanced course work – and about 10% have taken calculus or analytic geometry. Most high school calculus courses are taught for advanced placement (AP) credit; approximately 7.5% of high school graduates have taken AP calculus for one or more semesters.

How is course taking related to students' gender, race/ethnicity, and SES? It may be somewhat of a surprise that, in general, high school girls took as much mathematics in total and a slightly greater proportion of advanced mathematics courses than did boys (Table E1)[9]. At the same time, girls maintained a slightly higher mathematics GPA, 2.4 compared with 2.3 for boys.[10] Nevertheless, a higher percentage of boys took

[9] Cross-tabulations of course taking by gender, race/ethnicity, and SES are given in Appendix D.

[10] Not in the table.

AP calculus. The encouragement for boys to take calculus and the factors that discourage girls remain to be fully understood. A higher percentage of boys were classified as "remedial" or "slow starters," but a higher percentage of girls were classified as "modal" mathematics students. More boys were classified as "advanced," reflecting their tendency to take the most advanced course work including calculus. Asian students took the most mathematics, took the highest level of mathematics, and had the highest ratio of advanced- to beginning-level mathematics (1.8) of the four racial/ethnic groups studied. Approximately 21% of all Asian high school graduates took AP calculus. Asian students had the lowest percentage of students classified as "remedial" and the highest percentage classified as "advanced" in mathematics. Non-Hispanic White students had the second highest ratio of advanced- to beginning-level courses (1.6). White students did not accrue as many Carnegie Units as did Asian students, nor did they take mathematics for as many years or attain the same level of course work, on average, as did Asians. Approximately 8% of White students took AP calculus. The percentage of White students who took a remedial curriculum was slightly above that of Asians, but the percentage taking an advanced curriculum (13.1%) was well below that of Asians.

In some ways, the course-taking profiles of Hispanic students resembled that of non-Hispanic White students. The total number of units of mathematics taken was similar, as was the average number of years of mathematics (3.5). However, the distribution of courses is somewhat distinct. On average, White students attained a highest course level of 3.3 with approximately 26% of their course work taken at the introductory level (level 1). Hispanic students attained a highest course level of 3.1 with approximately 33% of courses at level 1. The resulting ratios of advanced- to beginning-level courses were 1.6 for White students and 1.2 for Hispanic students. Similar percentages of White and Hispanic students took a remedial curriculum, but smaller percentages of Hispanics enrolled in modal or advanced curricula.

The course-taking profile of African American students was below that of the other racial/ethnic groups. It may be due to the requirements of the schools they attend that African-American students take mathematics for as many years, on average, as other groups. However, they accrued fewer mathematics units in total, composed of a higher percentage of level-1 courses (37.7%), and compiled a ratio of advanced- to beginning-level mathematics courses (1.1) just slightly below that of Hispanic students. Only 2.7% of

African-American students took AP calculus. Approximately one fourth of all African-American high school graduates took a remedial curriculum, and only 5.8% took an advanced curriculum.

The differences in course taking between high-SES and low-SES students seem more extreme than those among racial/ethnic groups (with the possible exception of Asian students). Students on the free-lunch program accrued fewer mathematics units, did not reach as high a level, took substantially more level-1 courses, and had a substantially lower advanced- to beginning-level ratio of mathematics courses compared with students not receiving free lunches. Only about 3% of free-lunch students took AP calculus. Almost one half of free-lunch students took a curriculum classified as "remedial" or "slow starter" (49% in total), compared with 27.8% of non-free-lunch students. The relationship of course taking with student gender, race/ethnicity, and SES can only be understood in light of the tracks to which they have been assigned. The results in Table E2 show that track assignment is related to all three demographic characteristics. A higher percentage of boys was assigned to vocational tracks and a higher percentage of girls to academic tracks. The highest percentage of Asian students was assigned to academic tracks, followed by non-Hispanic White students, and then African-American and Hispanic students. The highest percentage of African-American students was assigned to vocational tracks, while the percentage of Hispanic students assigned to vocational tracks is much lower. A higher percentage of low-SES students than high-SES students was assigned to vocational tracks, and the reverse was true for academic-track assignments.

The track assignments of students according to demographic characteristics mirrors the course-taking patterns summarized in Table E1. The lower portion of Table E2 shows the association of course taking with track assignments. On every course-taking measure—total units, number of years, highest level, percentage of courses above level 1, ratio of advanced- to beginning-level courses—students in general tracks exceed their counterparts in vocational tracks and are exceeded by their peers in academic tracks. At the extreme, approximately 61% of vocational-track students took a curriculum classified as "remedial" and fewer than 1% took an "advanced" curriculum. The process whereby tracking determines the courses taken is not illusive. To the extent that tracking prevents students with the motivation and ability to engage in course work typified by a higher-level track, however, the discrepancies in track assignments must be addressed.

Course Taking and Other Student and Family Characteristics

Two concomitants of course taking were examined: students' postsecondary plans as reported in the NAEP background questionnaires and mathematics GPAs computed from the transcripts. The correlations between courses and GPAs are given in the bottom row of Table E3. These correlations are strong and consistent: Students who take more mathematics courses and who take higher-level courses obtain higher grades. Average GPAs increase monotonically as the level of the curriculum increases from "remedial" to "advanced." It is plausible that the effects are cyclical—that is, students who attain higher grades choose to take additional courses. At the same time, it is *not* generally the case that other students are raising their grades by remaining in less-than-challenging level-1 or remedial classes.

There is also a clear association of mathematics course taking with students' postsecondary plans. Students who expected to attend a 4-year college had a ratio of advanced- to beginning-level course work of 2.1, one of the highest ratios obtained in the entire study; approximately 13.5% of these youngsters had taken AP calculus. Students' plans are usually crystallized by Grade 12, the time at which the NAEP questionnaires were administered. Thus, it is not clear from this study the extent to which taking (and passing) advanced course work affected plans to attend a vocational school or college and the extent to which plans formulated in earlier grades influenced course-taking decisions. The role of school personnel in helping students begin to plan for the postsecondary years and to take courses in support of those plans requires further examination.

What characteristics of students' families encourage them to take advanced mathematics? The results in Table E3 indicate that parents' educational attainment is related positively to every index of course taking. At the extremes, students whose parents had not gone beyond high school accrued the fewest credits of mathematics and took over one third of their course work at the introductory level (level 1); over one fourth of these students took a remedial mathematics curriculum. Students whose parents had graduated from college accrued the greatest number of units of mathematics; approximately 13% of these individuals took an AP calculus course, and almost 20% took an advanced mathematics program. This relationship may be due to a number of factors including parents' modeling of education-relevant behavior, guidance provided for youngsters' course decisions, direct assistance with course work at home, and the greater encouragement to advance provided by the schools attended by higher SES students.

The role of parental modeling and assistance is represented partially by the literacy resources available at home. Although the correlations of home literacy with course taking are low, all are in the expected direction; that is, all are positive except the percentage of courses taken at level 1, which is negative. The mean level of home literacy increases monotonically as the curricular level increases from remedial to advanced. Given that the index of home literacy is composed of four simple items, these patterns represent at least modest support for the importance of home literacy to students' decisions to take challenging course work in mathematics.

Few factors hinder academic achievement as much as a student moving from one school to another. The impact on course taking is also evident from Table E3. Students who changed schools took as many years of mathematics as those who remained in the same school throughout their high school years (3.5 years, on average). Yet significant distinctions are clear between students who changed schools *one or more times* and those who did not. Mobile students—regardless of the number of moves—accrued fewer units of mathematics, did not attain as high a level of course work, and took a substantially higher proportion of their classes at level 1 than stable students. Almost one fourth of mobile students took only a remedial mathematics curriculum and only 5% to 8% took an advanced curriculum, in contrast to 15% and 14% of stable students, respectively. The negative impacts of school changes on course taking were almost identical for students who changed schools once and those who changed two or more times. Unfortunately, student mobility is not often under the control of school personnel or practices.

Objective 2: School Characteristics Related to Practices That Affect Course Taking

The primary question addressed in this part of the study concerned the poverty level of the school community. High-poverty schools were those serving high percentages of students who qualified for free lunches and who were Title I eligible. It is estimated that 50% of large city schools are high poverty, in comparison to 29.4% of schools in small communities and 18.3% of schools in small cities and suburban communities. By school size, approximately 29.4% of small/medium high schools are high poverty in comparison with 22.2% of large schools. The mathematics requirements of high- and low-poverty schools are given in Table E4. In total, about 38% of American high schools required 3 years (six semesters) or more of mathematics course work; the percentage is similar for low-poverty schools (37.0%) but somewhat higher for high-poverty schools (40.2%). Also, a slightly higher percentage of high-poverty schools required 2 years (four semesters) for graduation (51.1%) in comparison with 45.1% of low-poverty schools.

The correlations of the poverty indicators, enrollment, and urbanicity with practices that affect course taking are given in Table E5. Course offerings were significantly related to both poverty indicators and to school size. Lower SES schools and larger schools tended to offer fewer advanced mathematics courses in general and fewer semesters of calculus in particular. However, the ratio of advanced-to-basic offerings was not significantly related to SES or school size at this study's .01 level of significance. Larger schools, with greater numbers of teachers and classrooms, are able to offer more classes in total—both at basic and advanced levels; schools serving low-income student populations may offer fewer of each. Course offerings were related to school urbanicity, but the biggest difference was for schools serving small, largely rural, communities. Here both the number and proportion of advanced course offerings are less than in more urbanized settings.

Graduation requirements were not related significantly to any demographic characteristics of the schools, perhaps reflecting a reliance on common state or national guidelines. The percentage of students assigned to a vocational track was inversely related to the percentage of Title I students in a school but not to the percentage participating in the free-lunch program. The reasons for different correlations with the two indicators are not clear. The percentage of students in vocational tracks was greater in rural schools than elsewhere; this is consistent with the finding that fewer advanced courses settings—courses not usually taken by vocational-track students—are offered in these settings.

Similar patterns were apparent in the means when schools are classified into enrollment and poverty groupings (Table E6). The practices of rural schools stand out clearly in this table. Rural schools offered fewer advanced areas of mathematics, fewer calculus courses, and had a lower proportion of advanced courses than schools in other settings. Rural schools also had a higher percentage of students assigned to vocational tracks. The association of school size with urbanicity may affect the results for school enrollment, since most rural schools are in the "small/medium" classification. Examining the table by poverty levels, high-poverty schools offered fewer advanced courses and a smaller proportion of advanced courses, but they required slightly more mathematics for graduation than did low-poverty schools.

To examine the differences in a more complete context, a three-way ANOVA was performed to test the relationship of enrollment, urbanicity, and poverty with each school practice. The results are summarized in Table E7. School enrollment was significantly related to three school practices: the number of advanced areas offered, the number of semesters of calculus offered, and the percentage of students assigned to a vocational track. Larger schools offered, on average, close to one additional advanced area of study (mean difference = 0.83; effect size = 0.58ó), and almost one half additional semester of calculus (mean difference = 0.44; effect size = 0.31ó). Small schools had a higher percentage of students in vocational tracks.

School urbanicity, controlling for enrollment, was significantly related to the same three school practices—that is, the number of advanced courses offered, the number of semesters of calculus offered, and the percentage of students in vocational tracks. Tests of individual contrasts indicated that the differences in offerings between rural schools and urban/suburban schools were significant, but not the differences between large-city and urban/suburban schools. Rural schools offered approximately 0.41 fewer areas of advanced study (effect size = 0.80ó) and 0.47 fewer semesters of calculus (effect size = 0.49ó) compared with urban/suburban schools; rural schools also had a higher percentage of students in vocational tracks. Urbanicity was marginally related to the ratio of advanced- to basic-course offerings ($p < .028$), reflecting the lower ratio for rural schools in particular.

When enrollment and urbanicity were controlled statistically, the poverty status of high schools was not significantly related to any of the school practices with the exception of semesters of calculus offered. High-poverty schools offered approximately 0.34 fewer semesters of calculus, on average, than low-poverty schools (effect size = 0.49ó). To assess the possible impact of urbanicity on these findings, we retested with different orders of elimination. The results were essentially unchanged. When poverty was tested without controlling for enrollment or urbanicity, marginally significant differences were found for the number of advanced areas offered and significant differences for calculus; when poverty was tested controlling for enrollment, the only significant effect was for calculus.

Although calculus has been described as an important gateway course for many college majors, the general thesis of Oakes (1990) that advanced offerings are limited in high-poverty schools was not supported by our analyses. The means were in the direction postulated but the differences were not statistically significant. The possibility remains that, due to processes that occur within schools, students in high-poverty schools end up taking fewer advanced courses despite the schools' offerings.

With one possible exception, none of the interactions of enrollment, urbanicity, and poverty was statistically significant. The only interaction that was even marginally significant ($p < .02$) was enrollment-by-urbanicity for the number of advanced areas offered. Inspection of the means indicated that this was attributable to a small number (6) of large rural schools with an average well above all other enrollment-urbanicity groupings. The nonsignificant interactions document the generalizability of the other findings. In particular, the significant relationships of school enrollment and urbanicity with advanced courses offered—but not with the proportion of advanced courses —apply to high- and low-poverty schools alike. The nonsignificant relationship of poverty with offerings (except for calculus) is confirmed for large and small schools and for large-city, urban/suburban and rural schools alike. The nonsignificant relationships of all three school characteristics with graduation requirements again reflect a relatively uniform set of policies with respect to mathematics.

Objective 3: School Practices and Policies and the Courses Students Take

In this final phase of the study, we examined school characteristics and practices together with course-taking outcomes, with special attention to differential impact on minority students, students attending low-SES schools, and students assigned to different tracks. The HLM results are summarized in Table E8.

School Characteristics

School size was significantly related to the number of advanced areas and semesters of calculus offered by a school (Table E7), but it was not related to the courses students actually take. None of the tests of enrollment ("large school") in Table E8 even approached statistical significance.

The multivariate ("omnibus") tests[11] indicated that urbanicity was significantly related to the years of mathematics taken, the highest level taken, and the ratio of advanced-to-beginning course work. Tests of specific contrasts (Table E8) indicate these students the effect is attributable entirely to the disadvantage of students in rural schools. On average, these students took fewer years of mathematics (0.61σ), did not reach as high a level of mathematics (0.69σ), and took a lower ratio of advanced-to-basic mathematics courses (0.54σ) than did students in suburban/urban schools. The limited offerings of rural schools (Tables E6Eand E7) are reflected clearly in the courses students actually take.

The poverty status of schools was significantly related to the number of years of mathematics students take and marginally related to the highest-level mathematics course taken ($p < .05$). On average, students attending high-poverty schools took mathematics for fewer years than did students attending low-poverty schools (0.41σ). This difference reflects school practices rather than policies, however, since the years of mathematics required for graduation did not differ between high- and low-poverty schools. No systematic differences were found in the number of Carnegie Units accrued, the percentage of courses taken at level 1, or the ratio of advanced-to-beginning course work taken. The possibility of differential effects of offerings, requirements, and tracking on students in high- and low-poverty schools remains to be addressed.

Student Characteristics

Both race/ethnicity and gender were significantly related to mathematics course taking. Gender was significantly related to four measures: the number of years in which mathematics was studied, the number of Carnegie Units accrued, the highest level of mathematics reached, and the percentage of courses taken at level 1. Although males and females accrued similar numbers of Carnegie Units (Table E2), when statistical control was introduced for race/ethnicity and academic track, males took more years of mathematics (0.18σ), accrued more Carnegie Units of mathematics (0.10σ), and reached a higher level of mathematics

[11] Not tabled.

study (0.04σ) than did females. Males also took a slightly higher percentage of courses at level 1 than did females (0.06σ), suggesting greater variability in course taking by male students. The level-1 differences produced a marginally significant effect for the ratio of advanced-to-beginning course work ($p < .04$); females had a slightly higher ratio than did males (Table E2. In total, the gender effects were not large or highly consistent.

Multivariate ("omnibus") tests indicated that race/ethnicity was significantly related to all course-taking measures. Racial/ethnic groups were relatively homogeneous in terms of the number of years in which mathematics was taken; only Asian students stood out, taking mathematics for more years, on average, than other students (0.20σ). Asian students also accrued significantly more Carnegie Units in total (0.45σ), reached higher level course work (0.38σ), and took a higher proportion of advanced courses (0.18σ) than did White students, the second highest group on each measure. Asian and White students did not differ significantly on the percentage of courses taken at the lowest level (level 1).

Hispanic students accrued as many Carnegie Units as did non-Hispanic White students, but took a less challenging curriculum. Hispanic students took a higher percentage of courses at level 1 (0.38σ), did not reach as high a level of mathematics (0.34σ), and had a significantly lower ratio of advanced- to beginning-level course work (0.44σ). African American students took an even less rigorous curriculum. In total, they accrued fewer Carnegie Units of mathematics course work than did White students (0.15σ), took a higher percentage of courses at level 1 (0.58σ), did not reach as high a level of mathematics studied (0.52σ), and had a significantly lower ratio of advanced- to beginning-level courses (0.62σ). Among high school graduates, African American students have engaged in the least stringent set of mathematics courses of the four racial/ethnic groups examined in this study.

School Practices: Tracking, Offerings, and Requirements

Without exception, differences among academic tracks produced the strongest result of any effect studied in this investigation. Students in vocational tracks took substantially fewer and less challenging mathematics courses than students in general tracks, as indicated on all outcome measures (see Table E1);

effect sizes ranged from 0.65σ too 1.00σ. Students in academic tracks took substantially more and higher level mathematics courses than students in general tracks; effect sizes ranged from 0.55σ to 0.82σ. These findings are not surprising given the direct impact of track assignment on the courses a student takes.

Schools' course offerings were related systematically to the intensity of students' mathematics course work—that is, to the highest level reached, the ratio of advanced- to basic-level courses, to the percentage of courses at level 1 (inversely)—and marginally to the total number of Carnegie Units of mathematics students took. Although increased offerings allow students to take more advanced course work, the effect is not attributable to underlying demographic characteristics of high schools; the ratio of advanced- to beginning-level courses offered was not related significantly to school enrollment, urbanicity, or poverty (Table E7).

Graduation requirements were significantly related to the number of Carnegie Units of mathematics students acquired and marginally to the number of years in which they studied mathematics ($p < .02$). Requirements were not related significantly to any of the intensity measures, however, suggesting that increased requirements encourage students to take more mathematics course work than they might take otherwise, but not more advanced course work. Again, the effects are not attributable to the demographic features of schools, since graduation requirements were generally the same regardless of school size, urbanicity, or poverty level.

Equity: The Differential Impacts of Tracking, Offerings, and Requirements

As a first step in examining differential impact, we tested the interaction of the three practices and policies with the poverty level of the schools. If any interaction was statistically significant, we would examine the impact of practices separately among high- and low-poverty schools. In no case did an interaction term reach statistical significance, either when omnibus tests were conducted (for poverty-by-track) or in testing individual contrasts or predictor variables; of 25 tests of significance, only one *p*-value was below .05, while 18 were between .10 and .91. The effects of tracking, offerings, and requirements on course taking were very similar in high- and low-poverty schools.

Does *tracking* of students have different impacts on White and minority students? Prior analysis (Table E1) indicated that a somewhat greater percentage of African American students was assigned to vocational tracks, whereas greater percentages of White and Asian students were assigned to academic tracks. A similar pattern was exhibited with respect to SES: A greater percentage of low-SES students was assigned to vocational tracks and a greater percentage of high-SES students to academic tracks. In this analysis, we asked whether the differences in assignment were accompanied by different patterns of course taking. The omnibus test of the race-by-track interaction was statistically significant for all five course-taking measures; the patterns differed according to the specific racial/ethnic group.[12] Means of the course-taking measures are given in Table E9.

The one significant interaction contrast and two marginally significant contrasts for Asian students are attributable to unusually high course taking. For example, Asian students in general tracks took more years of mathematics than other general-track students. Asian students in academic tracks had the highest ratio of advanced-to-basic course work of any track-racial/ethnic group combination. In contrast, Asian students in vocational tracks displayed about the same course-taking patterns as did other racial/ethnic groups.

By and large, the tracking effect on African American students is similar to that for White students. The three marginally significant contrasts reflected the possibility that participation in an academic track was not quite as beneficial to African American students as it was to White students. For example, the advanced-to-beginning ratio for White students increased from 1.1 in the general track to 2.0 in the academic track. For African American students, the increase was only from 0.8 to 1.5. Hispanic students in vocational tracks took more years of mathematics and accrued more Carnegie Units than did White students in vocational tracks,[13] whereas the means of Hispanic and White students were similar in the general track. Most of the significant interactions for Hispanic students involved the academic track. In each instance (number of years, highest

[12] Recall that non-Hispanic White students comprised the comparison group for main-effect and interaction tests of significance.

[13] Our sample was comprised entirely of high school graduates, a possible source of bias especially among low-SES students or students enrolled in vocational tracks.

level reached, percentage at level 1, ratio of advanced-to-beginning) the benefit of participation in an academic track was not as great for Hispanic students as it was for non-Hispanic White students. As an example, the advanced-to-beginning ratio increased only from 1.0 for Hispanic students in the general track to 1.5 in the academic track (1.1 to 2.0 for Whites).

In sum, the interaction of tracking with race/ethnicity revealed that the effects of tracking are a matter of degree rather than distinct patterns. Vocational-track students generally took less mathematics and less advanced mathematics than did general-track students who, in turn, took less than students in academic tracks, regardless of racial/ethnic identity. There was little if any evidence that participation in a vocational track was more harmful to one group than another. To the extent that the analysis revealed consistencies, academic tracks were less helpful to African American and Hispanic students than to non-Hispanic White students.

Do schools' *offerings* affect minority and White students differently? According to the omnibus test, the interaction of offerings with race/ethnicity was statistically significant for the highest level of mathematics reached, the ratio of advanced-to-beginning course work, and the percentage of courses taken at level 1. The extent of mathematics offerings facilitated course taking differently for different racial/ethnic groups. Individual contrasts are summarized in Table E8; to explore in detail, we divided offerings into three equally sized groups and examined the means of the course-taking measures for each race/ethnicity.

Previous analysis revealed that advanced offerings were positively related to the intensity of students' mathematics courses (see above). In terms of the highest level reached, White students in schools with low, medium, and high offerings had average levels of 3.2, 3.3, and 3.5, respectively. In contrast, Asian students had averages of 3.3, 3.9, and 3.9. That is, Asian students reached the highest level of mathematics of any combination of offerings and race/ethnicity in the study—even in schools with moderate offerings. This is reflected in the ratio of advanced-to-beginning course work for Asians, which increases substantially in schools with moderate offerings and remains at about the same level in schools with high offerings.

Hispanic students took a high proportion of level-1 courses in schools with low offerings and took lower proportions—but not as low as did White students—in schools with moderate or high offerings.

Hispanic students in moderate- and high-offerings schools did not differ in the highest level of mathematics reached, attaining a relatively low average. The ratio of advanced-to-beginning course work taken by Hispanic students was greater in schools with moderate offerings but decreased somewhat in schools with high offerings. In general, Hispanic students were affected by schools' course offerings but not strongly or consistently. One feature stood out with respect to African American students: African American students who attended schools with high course offerings took substantially fewer level-1 courses than their counterparts in moderate-offerings schools.

Do offerings affect high- and low-track students differently? The interaction was statistically significant for all five course-taking measures. The reason was consistent: Students in vocational tracks did not realize any appreciable benefit from course offerings until the school's offerings were in the highest range. Students in general academic tracks, however, took more course work and higher-level courses even when the school's offerings were moderate. The ratio of advanced-to-beginning course work reflected this pattern; academic-track students in schools with moderate and high offerings attained high average advanced-to-basic ratios (2.0).

Do *graduation requirements* affect White and minority students, or students in higher and lower tracks, differently? Previous analysis indicated that graduation requirements were related to the total number of mathematics credits students accrue and, marginally, to the number of years in which students take mathematics (see earlier). The interaction of requirements with student race/ethnicity was not statistically significant for any course-taking measure. That is, students of all racial/ethnic groups tend to accrue more credits of mathematics when schools require more for graduation, but requirements do not affect the extent of advanced course work for any racial/ethnic group(s) in particular.

The interaction of graduation requirements with academic tracks, however, was statistically significant for every course-taking measure. To explore the interaction, we divided requirements into low (4 semesters or fewer) and high (5 semesters or more) and compared the means of the course-taking variables for each track. The pattern that emerged was clear and consistent. Graduation requirements had the biggest impact on students in vocational tracks: High requirements were accompanied by increased years of mathematics course work, greater numbers of Carnegie Units accrued, a higher level of mathematics taken, a smaller percentage of courses taken at level 1, and a somewhat higher ratio of advanced-to-basic courses taken. Requirements had a smaller but mixed impact on students in general tracks. The only clear finding was that high requirements were associated with somewhat greater course taking in general (i.e., years of study and Carnegie Units); other differences were negligible. Requirements had little or no effect on years of study, Carnegie Units, highest level reached, or percentage of courses at level 1, on students in academic tracks.

SUMMARY AND DISCUSSION

The primary objective of this study was to identify barriers that prevent high school students from participating fully in advanced course work in mathematics—a subject that provides important keys to postsecondary schooling. In this summary, we highlight three sets of findings: (a) the finding that school policies and practices affect students' course taking differentially within schools, (b) the finding that curricular track is significant in its own right *and* because students in different tracks are affected differently by course availability and graduation requirements, and (c) the findings regarding course offerings and course taking in small, rural schools.

The examination of school demographic features revealed that larger schools offered more advanced mathematics courses and small rural schools offered fewer. School enrollment and urbanicity were not related systematically to the proportion of advanced course offerings. Further, we found no systematic difference between high- and low-poverty schools either in the number of advanced courses offered or the proportion of advanced courses; the basic thesis of Oakes (1990) regarding course offerings was not supported. Graduation requirements were not related systematically to school size, urbanicity, or poverty level. *To the extent that students take different amounts of mathematics course work, the differences are attributable largely to practices that determine who will take particular courses.*

The examination of students' transcripts revealed similar results for school demographics and the courses students actually took. Course taking in mathematics was not related significantly to school enrollment, and the only effect of urbanicity was reduced course taking in rural schools. There was a significant association of course taking with the poverty level of the school; specifically, students in high-poverty schools studied mathematics for fewer years, on average, than did students in low-poverty schools. Since the graduation requirements of high- and low-poverty schools were similar, differences must again be attributed to processes that determine which students take particular courses.

Course offerings and graduation requirements have different impacts on students according to race/ethnicity and the curricular track to which students have been assigned. The extent of a school's mathematics offerings was significantly related to students' participation in advanced course work, a finding consistent with Lee et al. (1997). The effect of greater offerings was not as pronounced for African-American or Hispanic students as it was for White or Asian students, and was weaker for students in vocational tracks than those in general or academic tracks. The picture is clear and consistent: A school's decision to offer advanced mathematics provides an opportunity for stronger students to excel, but does not guarantee that other students will afford themselves of the same opportunity.

Graduation requirements, whether set by the state, district, or school, affect the number of courses students take. In general, our data showed that schools' mathematics requirements were significantly related to the number of Carnegie Units accrued, but not to the intensity of course work. Further, graduation requirements had a stronger impact on students in vocational tracks and, for this group, even increased the intensity of course work; vocational students in high-requirement schools took more advanced course work and fewer level-1 courses than their counterparts in low-requirement schools. Other questions remain unanswered, however, including the actual content of the advanced courses offered to vocational students and students' learning or performance in these classes. Merchant (1998) analyzed students' course taking before and after California legislation (SB 813) mandating increased course work in science and mathematics. Although course enrollments increased in both subjects, the number of courses failed also increased, especially among Hispanic students.[14] In the present study, courses failed are not counted in the total Carnegie Units accrued, but we did not examine

[14] At the time of this writing, an article by D. R. Lillard and P. P. DeCicca is in press in the *Economics of Education Review* reporting that dropout rates increase by 3% to 7% a year when high school graduation requirements are increased (see Olson, 2000).

grades received by groups of students identified by race/ethnicity, academic track, or in basic and advanced course work.

The results for curricular tracks were provocative. All measures of course taking showed large, significant differences among tracks: Students in vocational tracks accomplished less than students in general tracks who, in turn, accomplished less than students in academic tracks. The impact is felt disproportionately by students according to gender, race/ethnicity, and SES since males, African-American students, and low-SES students are more likely to be assigned to vocational tracks, while African American and Hispanic students are less likely to be assigned to academic tracks. Those who were assigned to an academic track, however, did not generally take as advanced course work as White students in academic tracks. African-American and Hispanic students suffer from the double whammy of race/ethnicity and track assignment on their course taking in mathematics.

The argument that tracking should be abandoned raises as many issues as it addresses. Attempts to eliminate tracking ("detrack") have been described as "a goal that is idealized more often than it is achieved" (Gamoran & Weinstein, 1998, p. 385). Barriers to detracking include the long tradition of separating students as a convenience to teachers and administrators. In mathematics, teachers' reluctance to detrack arise from their conceptions that the subject matter is highly sequenced and that students learn best when grouped with students at similar attainment levels (Gamoran & Weinstein, 1998). Indeed, many lower track students may not be motivated or able to learn the material presented in advanced mathematics classes—at least not without substantial additional support. Nor would detracking address the dilemma that students in higher tracks actually benefit from their placements (Brewer, Rees, & Argys, 1995; Gamoran & Mare, 1989; Hoffer, 1992).

Moderates in the debate argue that the extent of tracking should be reduced, placement criteria should be reevaluated, and low-track students should be provided a "pathway up" (e.g., Rosenbaum, 1999-2000). Transition classes have been attempted and evaluated in a number of communities; these have met with some success but do not always result in students bypassing other beginning courses or taking as many college-preparatory courses as students in academic tracks (White, Gamoran, Smithson, & Porter, 1996; Gamoran, Porter, Smithson, & White, 1997).

We believe that research and policy should take the latter direction, namely, toward making every attempt to channel motivated, able students into advanced course work and to provide pathways for students to change from one track to another. Our data indicate that most schools have adequate course offerings and requirements. The second stage of our model – Course taking = f (policy interpretation) – needs the greatest attention. In an illuminating analysis, Spade et al. (1997) noted that in higher SES schools, “the process by which students ... were placed in classes was more systematic ... [it] involved faculty and guidance counselors more actively” (p. 108). The student side of the equation is also important. The authors noted, “the lowest social-class districts...were less successful in getting students to enroll in 11^{th}-grade mathematics and science” (p. 118).

To temper the deleterious effects, research is needed that focuses on the roles of teachers and counselors in assigning students to *maximally challenging but realistic programs of study*, and the role of students themselves in making course decisions. For marginal students who may become more engaged or less engaged in academic courses depending on external sources of influence, the impact of teachers and counselors may be particularly important. The impact must be in the form of encouragement—not only to take advanced courses but to formulate *challenging but realistic postsecondary plans* and to understand the relationship of high school courses to attaining those goals. Research must illuminate both the positive and negative roles of significant others in students' decision making. Further, the real and potential effects of crystallized plans for the future (Powell & Luzzo, 1998) and the utility of course work in fulfilling those plans must be examined in depth.

This investigation uncovered one other issue regarding course taking that was less expected: the plight of students enrolled in small, rural schools. We began this investigation with a special concern for large, inner-city schools serving high-poverty communities. Although the problems endemic to such schools remain, we found small rural schools to be distinct from all others. In 1993-1994, approximately 1.1 million public-school students were enrolled in small rural districts; in some parts of the country, student bodies are composed of particular minority groups, for example, Native American students (McLaughlin, Huberman, Hawkins, & Hoffman, 1997). Teachers in rural schools are generally younger and less well educated than their nonrural counterparts (Stern, 1994).

In the present study, we found that the mathematics offerings of rural schools were substantially below those of schools in other settings—both among high-poverty and low-poverty rural schools. The percentage of students assigned to vocational tracks was greatest in rural schools. And both the number of years of mathematics taken and the intensity of mathematics studied (highest level; ratio of advanced-to-beginning) were inferior among students attending rural schools. Whether this reflects the policies and practices of the school or the choices made by students, the limited mathematics curriculum taken in rural schools restricts students' opportunities for postsecondary accomplishments. More attention to this problem is needed.

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