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ABSTRACT

This paper examines some of the determinants of the length of time, in terms of Carnegie units of mathematics taken, that individuals spend studying mathematics in high school. Particular attention focuses on how gender and race combine to influence the amount of mathematics students take. Data from the National Education Longitudinal Study of 1988 were used. Results include: (1) Hispanics typically terminate the study of mathematics before African Americans, and both of these populations are at a significantly higher risk than white or Asian students of concluding their education in mathematics early; (2) father's education, previous grades in mathematics, and graduation requirements are all factors that contribute to a student's decision to terminate the study of mathematics; and (3) once the preceding factors are controlled for, African American males, Hispanic males, and White females are at the highest risk of discontinuing their study of mathematics. Contains 60 references. (MKR)

Analyzing the Amount of Time a Student Studies Math

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1. Introduction

There is a tremendous amount of literature devoted to the study of mathematics and why students do or do not succeed in math. Those who stay in school, receive a high school diploma, and intend to go to college need to take math and to many students that is an unappealing thought. Too few math classes may become an obstacle for admission into post-secondary education. This paper examines some of the determinants of the length of time, the quantity of math taken by a student measured in carnegie units, individuals spend studying mathematics in high school. Particular attention will focus on how gender and race combine to influence the amount of math one studies.

Students display differences in mathematical achievement from the first time their performance is evaluated. Initial math aptitude and participation in math courses are likely the two biggest factors that determine how well a students achieves in math (Chipman & Thomas, 1987; Raizen & Jones, 1985; Wise, 1985). Initial achievement and participation are not necessarily independent of each other. Enrollment in math classes will vary from student to student, but often there is a high correlation between initial achievement and course selection (Chipman & Wilson, 1985). Initial achievement, however, is out of the control of educators in high schools. Therefore secondary educators are left to concentrate on the enrollment of students in math classes to help students achieve their potential. Important differences in math achievement among students can be accounted for by considering the number of math courses taken, or the number avoided, in high school (Wolleat et al., 1980). Periods of time during which significant numbers of students of a particular race and gender terminate the study of mathematics and how different influences sway a student's decision to quit studying math will be the primary foci of this paper. In order to examine participation in math, the outcome of math education will be the amount of math taken.

The next section contains a review of the literature that suggests specific factors that could influence a students decision to continue or terminate the study of mathematics in high school. Section 3 presents the model that will be utilized in this study. Some of the factors suggested by researchers and presented in section 2 will be used as independent variables in the next section that applies survival analysis. Duration models of studying mathematics are estimated in section 5 of this study. Concluding remarks follow in last section.

2. WHAT FACTORS MIGHT AFFECT THE QUANTITY OF MATHEMATICS A STUDENT STUDIES

The participation level of girls and certain ethnic groups (African Americans and Hispanics) in advanced mathematics courses has traditionally been lower than that of many of their classmates (Fennema & Sherman, 1977; Meyer, 1989). Gender gaps in mathematics participation have been particularly visible within various minority or ethnic groups (Chipman & Thomas, 1985). The work of many researchers suggests that the enrollment gap is narrowing but differences continue to persist as all subsets of the population are now taking more mathematics

(Johnson, 1989; Linn & Hyde, 1989; Meyer, 1989; Patterson, 1991). Results from The Fourth Mathematics Assessment suggest that African Americans have made bigger gains than Hispanics (Johnson, 1989). Data collected from Project TALENT showed that sex differences in math achievement could be explained by participation in higher level, elective math courses (Wise, 1985). Typically White boys, and African American and Hispanic girls excel in math during high school, perhaps due to societal expectations or the importance placed on the sex-role type (Chipman & Thomas, 1987; Good and Findley, 1985; Moore & Smith, 1987).

Generally females in advanced math courses, particularly White females, are a more select group because they tend to be exceptionally critical of their own performance in mathematics (Wise, Steel & MacDonald, 1979). Often they will choose not to enroll in a math course for which they are qualified but may not excel (Eccles et al., 1985). Additionally, girls have traditionally been less likely to take shortcuts useful for solving problems quickly on timed tests (Linn & Hyde, 1989). Consequently, for reasons unrelated to their ability and directly associated with their desire to follow directions or learned procedures and do well in school, they do not appear to do as well in mathematics. For this and other reasons there are typically more boys than girls in higher level math classes and therefore the majority of students in college majoring in mathematical or scientific areas have been men (Chipman & Thomas, 1987; Raizen & Jones, 1985).

Opportunities for post-secondary education and particular degrees will be determined in part by the selection of math courses at the secondary level. Mathematics courses can serve as a filter that separates people into groups with distinct and well-defined life possibilities. Four years of high school math is sometimes required for entrance into the most competitive and reputable post-secondary programs (Armstrong, 1985; Meyer, 1991). A weak background in math may limit the potential of many students to earn positions of power or secure a high paying job (Brush, 1985; Stanic, 1991). Some researchers go considerably further and suggest that disparities in mathematical ability could contribute to serious problems in the way society functions and the social class stratification (Johnson & Packer, 1987).

In order to encourage all students to take more math courses and ideally decrease any disparities between the sexes and among different racial groups, many states increased graduation requirements in math and science during the 1980's (Raizen & Jones, 1985). This is an example of one of the few policies that has been established to help students achieve in math by requiring them to increase their exposure to mathematics during high school. Research has suggested that course enrollment is a function of school policies to some degree (Chipman & Thomas, 1987). These educational reforms did not generally change enrollment patterns of middle or upper class students, but they had an important impact on at-risk students who generally have a lower socioeconomic background and are typically underrepresented in more challenging, elective math courses (Moore & Smith, 1987; Patterson, 1991).

If socioeconomic status is a significant factor in the prediction of math enrollment and therefore math achievement, as has been suggested by research, then the problem is a self-perpetuating one. Research contends that the socioeconomic status of the school and student, and the race of the pupil are highly correlated to math enrollment and achievement (Brush, 1985; Chipman & Thomas, 1987; Chipman & Wilson, 1985; Kohr et al., 1991; Wise, 1985). African American students may be more impaired by low socioeconomic schools than White students (Kohr, 1991). Poverty, language difficulties and cultural differences may cause some students to exit math prematurely and therefore they never achieve their potential (Chipman & Cocking, 1988). In light of all of this research, an important question arises: Which of the factors suggested by research contribute to a student's decision to terminate their enrollment in math during high school?

This question is particularly interesting when one questions whether enrollment in upper level math courses may be related to gender because girls as a group generally do better than, or at least as well as, boys in grade school mathematics (Good and Findley, 1985). There is evidence that ability differences favoring girls exist between the sexes at every age during grade school, but beginning sometime during middle school boys begin to excel past their female classmates and this push continues through high school when mathematics courses include more electives (Moore & Smith, 1987). According to the 1977-78 National Assessment of Education Progress and the Fourth Mathematics Assessment there is no significant difference between the participation of males and females in Algebra and Geometry (Anick et al., 1981; Meyer, 1989). The Fourth Mathematics Assessment test found that there is a statistically significant difference between the sexes favoring males in advanced math courses (Meyer, 1989). At this level males generally excel at math and females often find it boring or too challenging (Good & Findley, 1985).

This may cause one to question if there is equal opportunity for all students to achieve in mathematics. Theoretically there is nothing that is deliberately done to keep females, poor people or certain ethnic groups from studying math, but research shows that there do exist differences between the students who take and do not take higher level math courses based on these characteristics and this brings the assumption of equal opportunity to learn math into question (Meyer, 1991). Perhaps not all members of the population are equally encouraged to continue to enroll in math classes during high school.

At some points in history discouragement was conspicuous. Girls were told in the eighteenth century that too much education might hurt their chances for marriage. It seems unlikely that the myth that math is unfeminine can continue to prosper, but perhaps today girls are self-conscious about being too smart, too schooled or too good at math. One hopes that girls today would not believe the old tales that they cannot learn math because their heads are too small, their nervous system too delicate or their reasoning capacities insufficient. These ideas were publicized by the likes of Rousseau who theorized that the brains of women were unfit for research in abstract areas such as math or science (Armstrong, 1985).

Though these tales are hopefully passé, research suggests that differences in participation rates of boys and girls in math classes persist. Decades have passed since it was suggested that girls could not do math for a biological reason, but there continues to be speculation that there is a genetic explanation for why boys outperform girls in mathematics (Armstrong, 1985). Researchers have observed persistent differences in mathematics ability between the sexes and some still suggest that conceivably these differences are a result of biological differences. Therefore differences in enrollment patterns and consequently in selection of math-related careers would be due to natural differences in math ability, specifically in spatial ability (Good & Findley, 1985; Linn & Hyde, 1989; Meyer, 1989). Research has given no tangible reason to believe there exist inborn differences between white males, the "majority", and the "minority" which could account for differences in achievement (Cocking & Mestre, 1988).

Fennema (1977) focussed on two affective variables that explain most of the sex differences in math: anxiety about learning math and the stereotype of math as a male dominated area of study. It has been suggested that math anxiety causes individuals to avoid math classes and this apprehension has directly or indirectly caused some of the obvious differences in achievement between the sexes (Good & Findley, 1985; Wilhelm & Brooks, 1980). This may be somewhat related to the finding that the occupation of a girl's father and his educational attainment are often significant predictors of math achievement (Wise, 1985). It is proposed that boys or girls who identify with the male role-model do better in math, especially if the male role-model is in a mathematical or scientific career (Armstrong, 1985). Careers and hobbies that are typically held by men (working with tools, cars and appliances) and boys (playing with geometric or mechanical toys and participating in sports) reinforce concepts in math, particularly spatial skills, and are another possible cause of sex differences in math achievement (Good & Findley, 1985; Linn & Hyde, 1989).

Researchers question if females view achievement in math as a potential conflict with their mother's role or other learned social stereotypes. For example a career utilizing mathematics may be considered an inflexible occupation for a family or a spouse's career. This problem may be systemic because generations of females may not be motivated to achieve in math and therefore they will not enroll themselves in mathematics courses (Armstrong, 1985; Chipman & Thomas, 1987; Eccles et al., 1985; Good & Findley, 1985; Wilhelm & Brooks, 1980). On the other hand males generally have a higher perceived utility for mathematics than females and therefore they may work more diligently in class and do more homework. It sometimes becomes difficult to determine the cause and effect relationship between achievement and effort in situations such as this (Chipman & Wilson, 1985; Moore & Smith, 1987; Raizen & Jones, 1985).

We need to examine if girls and members of other ethnic groups stop taking math inordinately early, and if this is the case it needs to be assessed why they leave and when this exodus takes place in order to take steps to reverse the process. Countless other studies have been conducted using some combination of the variables previously discussed and others too numerous to mention. These researchers have generally conducted their analysis and reached their conclusion by employing multiple regression techniques. Analysis will be conducted using a different statistical technique to evaluate periods during which certain groups are at a high risk of terminating the study of mathematics and determining factors that put students at greater risk.

3. A DURATION MODEL TO STUDY ENROLLMENT IN MATHEMATICS COURSES

This paper develops a model to examine high school students exiting the math curriculum. This model assumes that students individually choose whether or not to continue to study mathematics. Background information about individual students and their enrollment in mathematics courses is the data used in the study. In addition to being concerned with whether or not an event (terminating the study of mathematics before four years of study) happens, this model also provides information about when it happens. Enrollment decisions are based on many factors including past experiences and characteristics. The number of Carnegie units in which a student is enrolled in a mathematics course is the solution to the dynamic programming problem. In order to study when an event such as a student exiting the study of mathematics happens, duration modeling is used.

The model is formulated as a discrete-time and discrete-choice model. Each individual in the study makes one discrete choice at each time interval. Individuals decide to continue to study math or quit. In other words the students decide when to leave or the duration of time they choose to participate. Duration models are also referred to as survival analysis because the research question being asked could be "How long did the student survive math?".

This type of model is appropriate for many types of study, including analyses of dropout rates, teacher attrition, life expectancy, spells of unemployment, length of marriage, duration of wars and the timing of bank transactions. The present study deals with how many Carnegie units of mathematics a student completes before terminating the study of mathematics. One benefit of this type of model is the possibility of determining particularly risky periods of time in a student's academic career. These times are detected by changes and increases in the slope of the survival function or increases in the hazard function. Individual data are used in this model so characteristics can differ for each person in the study. No averages are used in this study, which is an improvement upon some previous studies.

Another advantage of this type of study is that it includes students who have stayed in math until the end of the study. These data are considered "right-censored" because at the end of data collection the question "When did it happen?" had not been answered. Other studies exclude this data because the question of interest has not been answered so there is no value that can be assigned to the variable. Individuals in the study for whom the question "When did it happen?" was answered before data collection began are considered "left-censored". It is important that those with censored data be included in the study or it will be biased toward the group in the middle. In all likelihood a model would suggest that time spent studying math is too short if censored data is ignored because all of the students who continued to be enrolled in math through the end of high school would have been dropped because they did not do the monitored activity (quitting math) before they completed high school. Survival functions are used to reduce problems associated with censored data.

Survival analysis has many of the same advantages of multiple regression. Many predictor variables can be included in one model in order to examine simultaneously their combined effects on the dependent variable. Fitted models are used in multiple regression and survival analysis to explain the effects of independent variables. Both continuous and categorical variables can be used to predict how much math a student will study. Survival analysis has two characteristic benefits. First, it allows the researcher to incorporate predictor variables that change over time (annual salary, minimum wage, or the political party of the president for example). Additionally, one can test if the effect of a predictor variable changes with time (Willett & Singer, 1989). Like multiple regression models, this survival analysis has a dependent or outcome variable, the amount of time spent studying math.

Achievement in math is be represented in this paper by the number of Carnegie units of math completed. This dependent variable is not typically employed. Other researchers have used achievement test scores to measure attainment. There are two flaws with these measures. First, achievement tests are fairly elementary and they measure the basics, thus they do not distinguish students at all levels accurately. Second, and very important, achievement test scores only represent students who are in school. Therefore the studies using test results ignore the students who have dropped out or who did not take the test. This is particularly important for ethnic or socioeconomic groups with high dropout rates because their scores will appear inordinately high since they will be calculated only on the basis of those who remained in school

(Arias, 1986). The model presented addresses this problem by including all students, even those who have dropped out, in the study.

4. SURVIVAL ANALYSIS

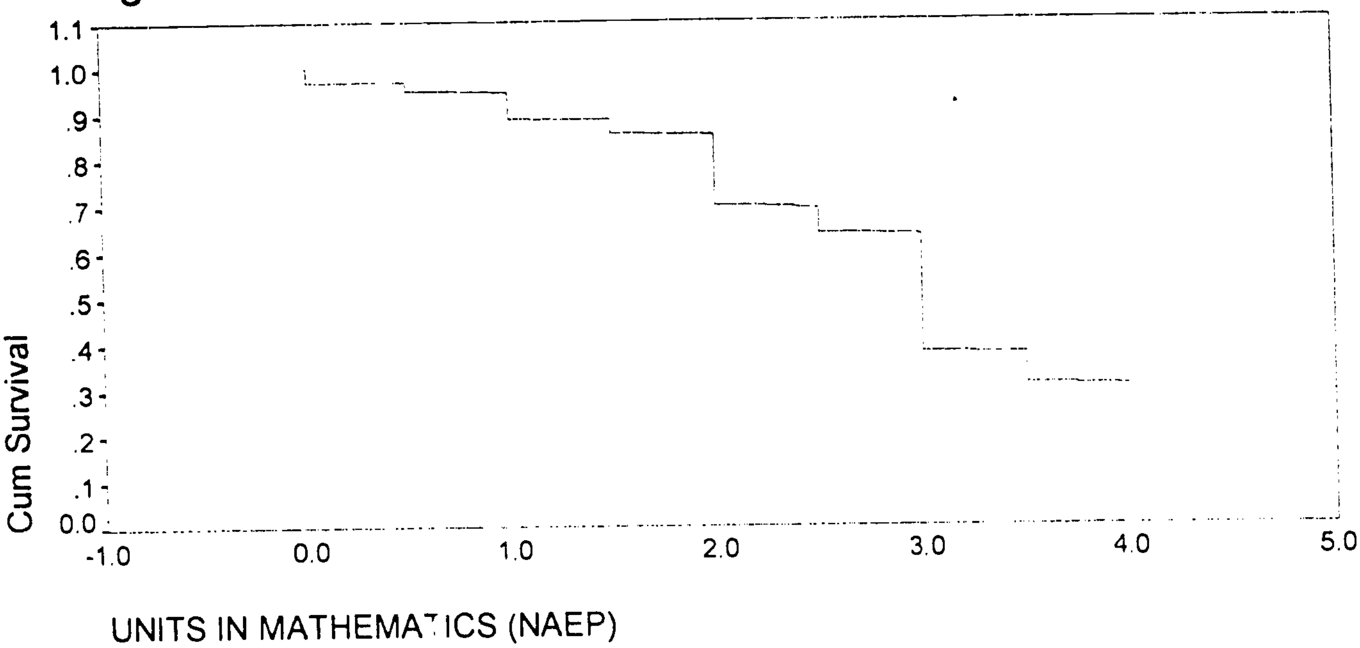
To graphically examine who quits taking math and when they decide to terminate coursework in math, survival functions will be used. The survival function is a probability that an event continues to occur plotted against time. This is different than the hazard function, since it detects changes in the slope of the survival function and therefore allows for identification of particularly risky periods of time when the likelihood of termination of math is relatively high. The central concept of this method is the conditional probability that an event, discontinuing the study of mathematics in this case, occurs at a specific time.

To begin to examine when students terminate the study of mathematics data from the National Education Longitudinal Study (NELS) of 1988 (base year, first follow-up, and second follow-up) will be used. The longitudinal data will be used to track the enrollment of students in mathematics courses and identify factors that may have contributed to their decision to continue or terminate the study of mathematics. The term survival probability typically refers to the fraction of the population of interest that survives through each successive time period. In this study the survival probability would indicate the percentage of students in the nationwide study that remained in at least one mathematics course through successive years in secondary school The survival function is a plot of the survival probabilities against time. Survival functions provide summary illustrations of student enrollment in mathematics courses. The decisions of 16,489 students to continue or terminate the study of mathematics are shown in the survival function Figure 1. At the beginning of secondary school, units of mathematics = 0, all of the students survive and the survival probability is one. Half of the students continue to take math courses until after they begin their third year of math. The point when the probability of surviving equals 0.5 is significant because it is the median lifetime, the time at which half of the sample survives math and half does not. As time, measured in Carnegie units, progresses students decide not to continue the study of mathematics and this causes the survival function to fall. Note that not everyone has terminated the study of math before they have completed four years of it and therefore the survival function never reaches zero.

In Figure 2 separate survival probabilities are drawn for males and females who participated in the study. This shows how similar their participation rates were through four years of high school math. Contrary to much of the existing literature, girls appear to continue to study math longer through the beginning of high school. The slightly higher survival probability of females appears to continue until after the third year of math is completed. During the fourth year of math males in the study emerge with somewhat higher survival probabilities. This is consistent with research that has suggested that males are generally better represented in higher level math classes. But, contrary to much of the literature, more females than males in this study continue to study math through most of their high school years.

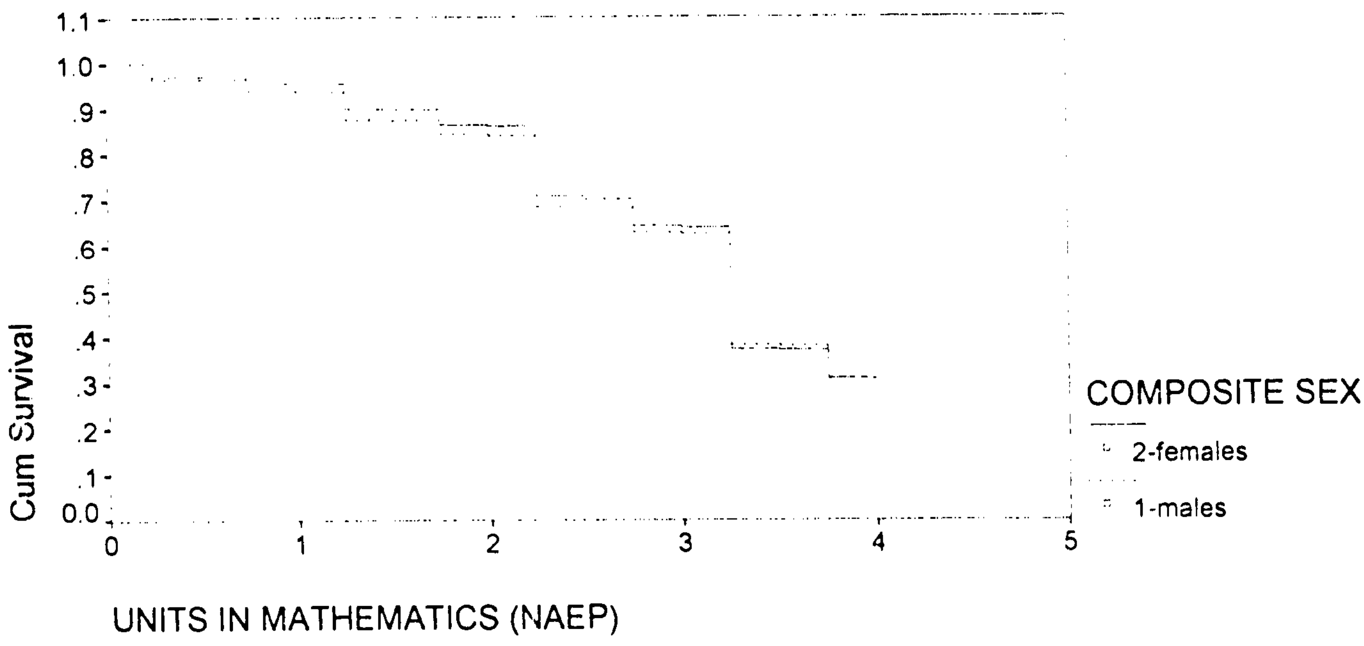
The literature also suggests that certain races achieve better in mathematics than others. There have been claims that the inequities in the American education system become manifest in, among other places, mathematics classrooms across the country in which Whites and Asian Americans are typically well represented and Hispanics and African Americans are not. The survival function resulting from the data collected in this study support this suggestion. Whites

figure 1 - Survival Function



Cases weighted by RDWT

figure 2 - Survival Function



Cases weighted by RDWT

and Asian Americans have higher survival probabilities than Hispanics and African Americans at every time that a student could choose to conclude their study of mathematics (Figure 3). The survival function is notably flatter for Asian Americans who considerably outlasted Whites in mathematics courses. African Americans continued in mathematics longer than Hispanics whose survival function is the steepest of all of the subpopulations.

Finally males and females are compared within each of the racial groups. All of these survival functions, like those already discussed, are monotonically non-increasing functions of time. Female Asian Americans and Whites have higher survival probabilities than their male counterparts during the first years of high school (Figures 4 and 5). Sometime after the second and third years of math respectively, the survival probabilities of Asian American and White males begin to exceed the females. In other words, the male students who have continued to study mathematics past these specific times have a higher probability of continuing to study mathematics than the female students who are at the same point. After the third year the male and female Asian Americans have almost identical survival functions. Similarly Hispanic females tend to outlast Hispanic males until after the second year at which time the males are more likely to persevere (Figure 6). Figure 7 illustrates that the African American population differs from the others, African American females have a higher survival probability at all times. In other words, at every opportunity that a student has during high school to discontinue the study of mathematics, African American males are more likely than females to choose to do so. The difference between the two populations survival probabilities appears to be fairly significant after the third year of mathematics.

figure 3 - Survival Function

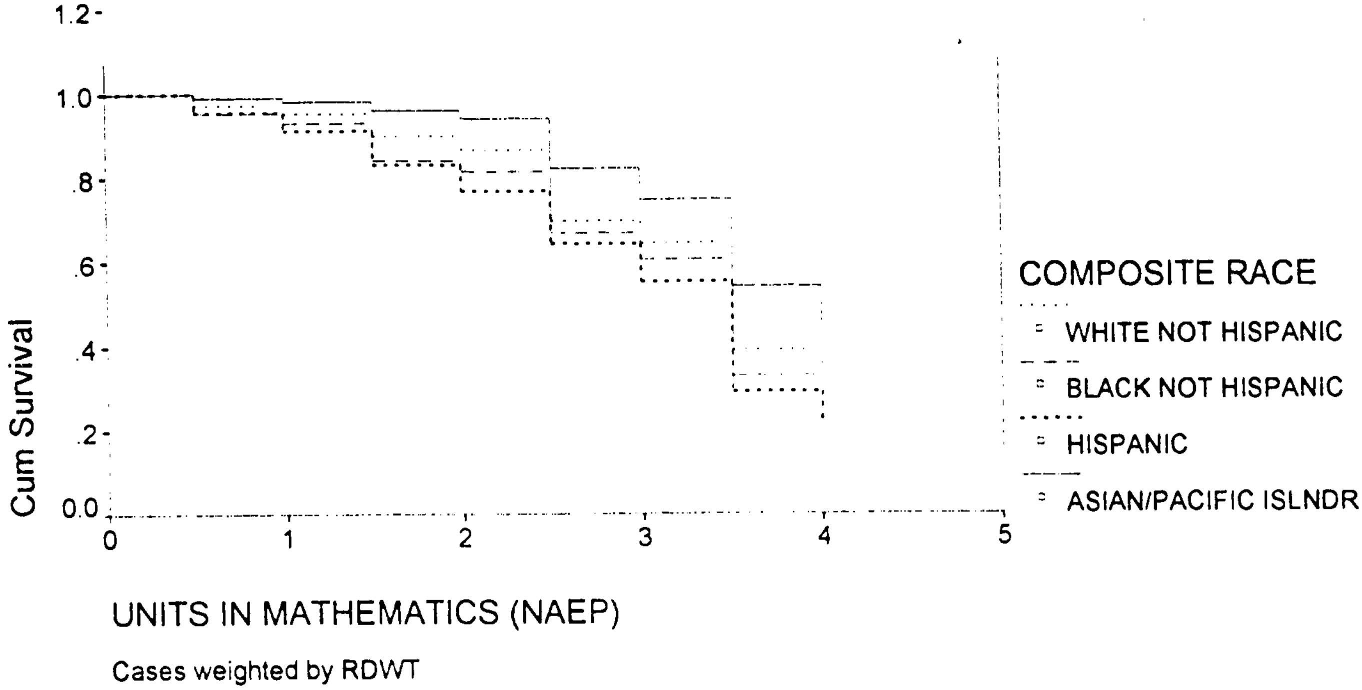


figure 4 - Survival Function

race = Asian American/Pac Islnd

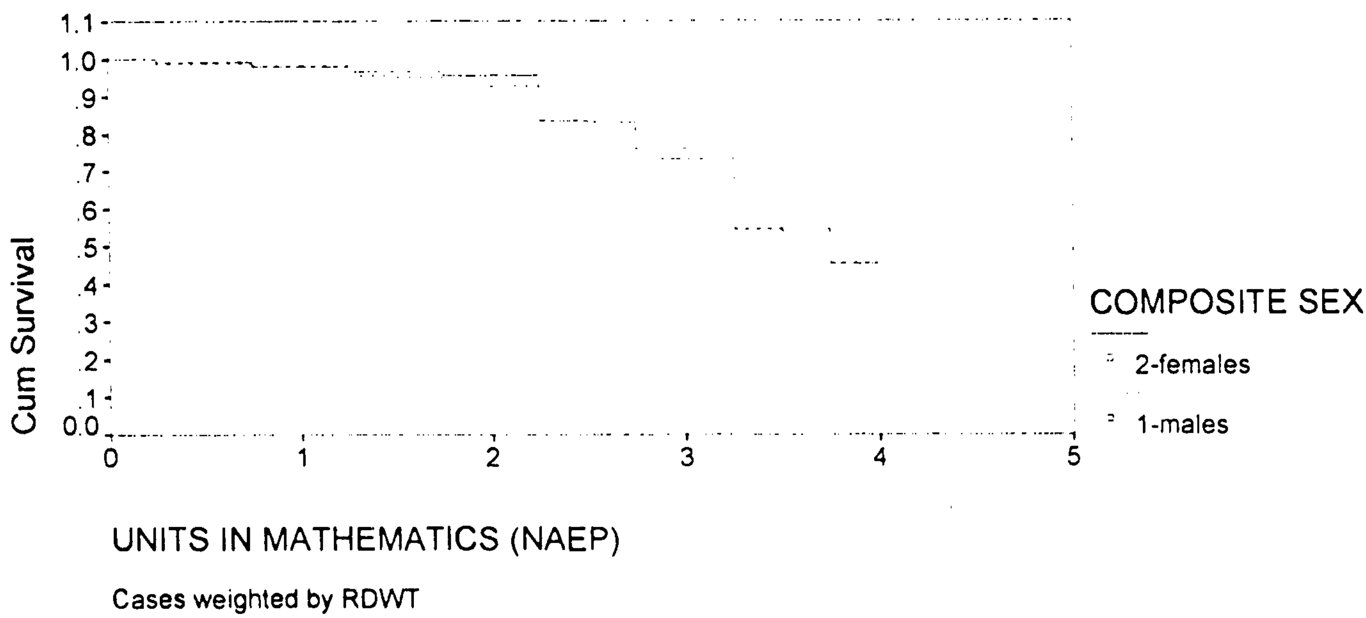


figure 5 - Survival Function

race = White

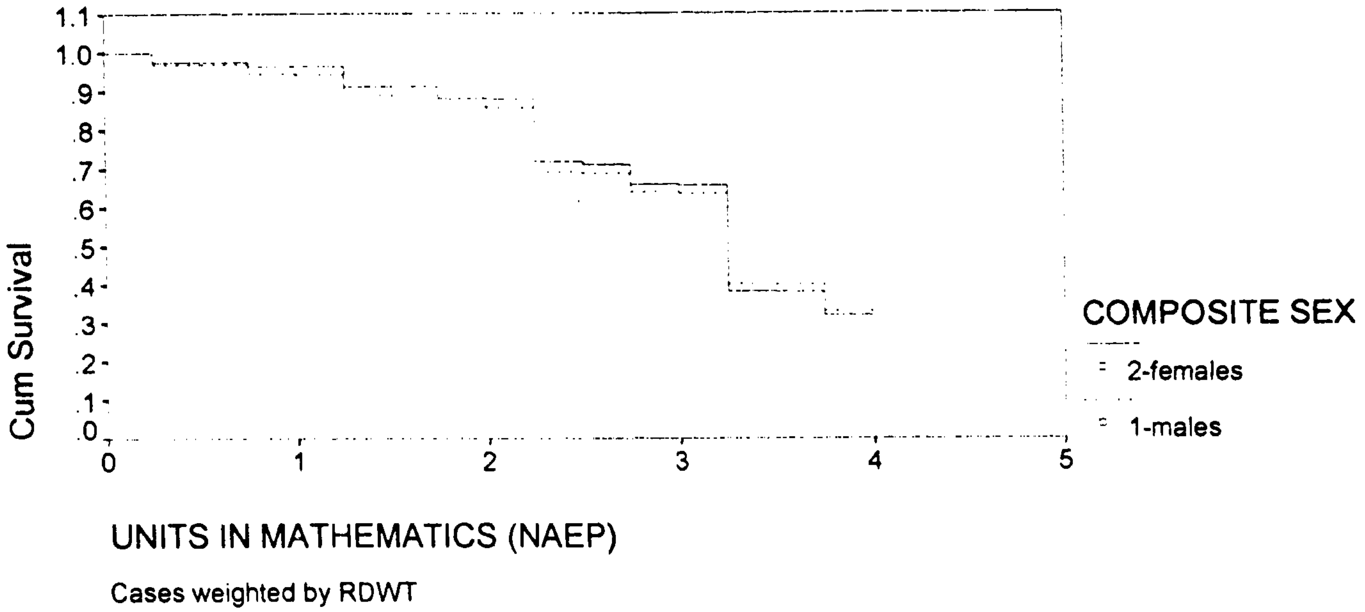


figure 6 - Survival Function

race = Hispanic

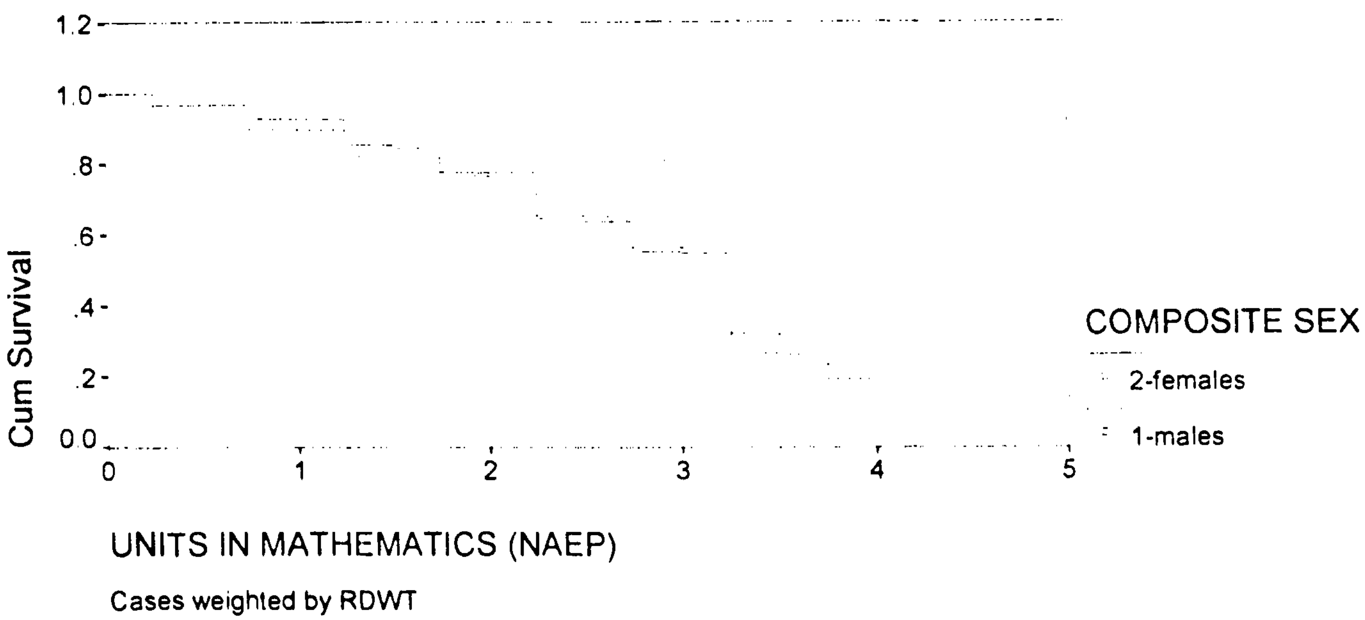
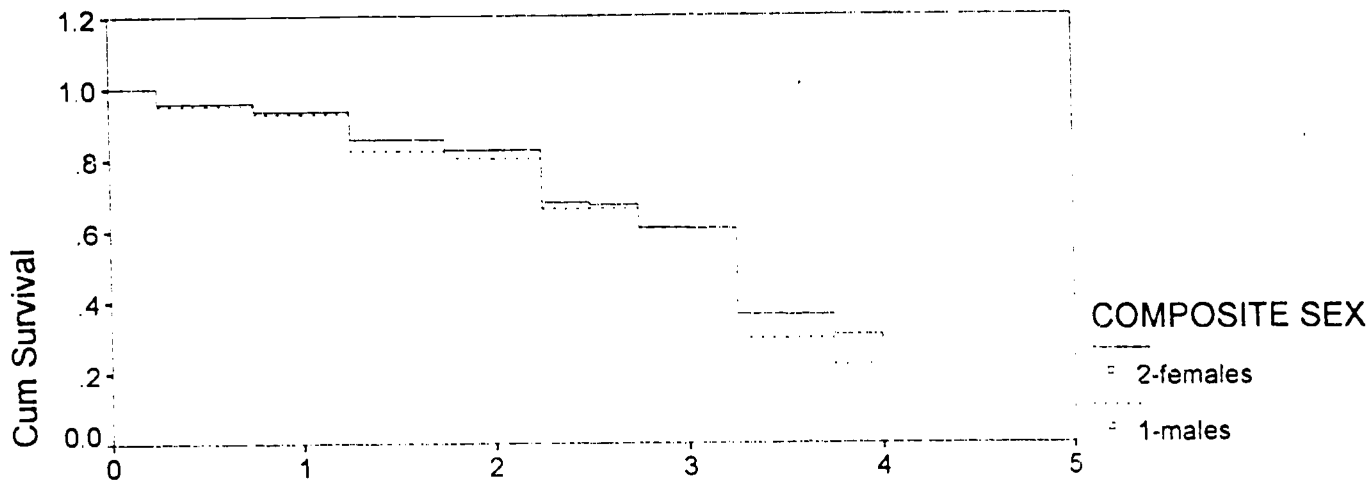


figure 7 - Survival Function

race = African American



UNITS IN MATHEMATICS (NAEP)

Cases weighted by RDWT

5. EMPIRICAL RESULTS

This section estimates duration models of studying mathematics. Using the NELS data the periods of greatest risk for terminating the study of mathematics can be identified. The distribution of risk can be calculated for all of the students as well as for certain subpopulations. The first column of Table 1 lists the interval start time, measured in Carnegie units completed of mathematics. The second column of this table contains an estimate of the probability that a student will continue to study mathematics and complete that Carnegie unit given that he or she has "survived" or continued to study math until this point. This value is calculated as the number of students who begin the next Carnegie unit of mathematics divided by the number of students who began that Carnegie unit. The third column is the probability a student will begin a Carnegie unit and terminate the study of mathematics before continuing to the next course. It is equal to the difference between one and the probability in the second column. The fourth column contains an estimate of the probability of a student's surviving in the math class until the end of that time interval. This figure is computed as the product of the proportion surviving this interval and the proportion surviving all previous intervals (for example 0.6324 = 0.7425 * 0.8998 * 0.9466). The last column is an estimate of the probability per unit of time that a student will begin a year of math and decide to discontinue the study of mathematics before beginning the next year. The numbers listed in this column are the hazard rates, the exit rate per unit of time, associated with each year of mathematics.

Table 1 - When do students decide to terminate the study of mathematics?

Interval start time	Proportion Surviving	Proportion Terminating	Percentage Surviving	Percentage Terminating
0	0.9466	0.0534	0.9466	0.0549
1	0.8998	0.1002	0.8518	0.1054
2	0.7425	0.2575	0.6324	0.2956
3	0.4821	0.5179	0.3049	0.6989

Note that this study looked at exit behaviors of students who completed fewer than four years of mathematics. Students who completed four or more years of math coursework were included in the study, but the times at which they decided to conclude the study of math was not of interest. As stated earlier these students never did the act of interest, terminating the study of math, before completing four Carnegie units in high school.

The same figures can be calculated for different subpopulations. Below, in Tables 2 and 3, the same summary statistics are figured for males and females. These numbers are consistent with the survival functions presented earlier that separated the population by gender (Figure 2). Note that the hazard probabilities are higher for males in early years and for females in later years. This is consistent with the survival functions that were higher for girls earlier and higher for boys in the higher level math classes. Only during the fourth year of mathematics are boys more likely than girls to still be enrolled in math classes.

Table 2 - When do male students decide to terminate the study of mathematics?

Interval start time	Proportion Surviving	Proportion Terminating	Percentage Surviving	Percentage Terminating
0	0.9372	0.0628	0.9372	0.0648
1	0.8978	0.1022	0.8415	0.1077
2	0.7434	0.2566	0.6255	0.2944
3	0.4886	0.5114	0.3056	0.6872

Table 3 - When do female students decide to terminate the study of mathematics?

Interval start time	Proportion Surviving	Proportion Terminating	Percentage Surviving	Percentage Terminating
0	0.9565	0.0435	0.9565	0.0445
1	0.9019	0.0981	0.8626	0.1032
2	0.7416	0.2584	0.6397	0.2968
3	0.4754	0.5246	0.3041	0.7111

Finally the same estimates are calculated for each of the subpopulations previously discussed. On Table 4 the estimates described earlier are calculated separately for males and females in each of the racial or ethnic groups (Asian American, African American, Hispanics and Whites) previously utilized. The results presented in this table are also consistent with the survival functions plotted in Figures 4, 5, 6 and 7 in the previous section. Note that the hazard rates are higher for both male and female African Americans and Hispanics than for Whites and Asian American at every time period.

Table 4 - When do male and female students in different ethnic groups decide to terminate the study of mathematics?

Interval start time	Subpopulation	Proportion Surviving	Proportion Terminating	Percentage Surviving	Percentage Terminating
0	Asian Am Females	0.9790	0.0210	0.9790	0.0212
	Asian Am Males	0.9825	0.0175	0.9825	0.0177
	African Am Females	0.9343	0.0657	0.9343	0.0680
	African Am Males	0.9275	0.0725	0.9275	0.0753
	Hispanic Females	0.9282	0.0718	0.9282	0.0745
	Hispanic Males	0.8968	0.1032	0.8968	0.1088
	White Females	0.9639	0.0361	0.9639	0.0368
	White Males	0.9424	0.0576	0.9424	0.0593
1	Asian Am Females	0.9741	0.0259	0.9536	0.0262
	Asian Am Males	0.9439	0.0561	0.9273	0.0578
	African Am Females	0.8842	0.1158	0.8260	0.1230
	African Am Males	0.8658	0.1342	0.8030	0.1439
	Hispanic Females	0.8347	0.1653	0.7748	0.1802
	Hispanic Males	0.8517	0.1483	0.7638	0.1601
	White Females	0.9111	0.0889	0.8782	0.0931
	White Males	0.9077	0.0923	0.8554	0.0968
2	Asian Am Females	0.7677	0.2323	0.7321	0.2628
	Asian Am Males	0.8209	0.1791	0.7613	0.1967
	African Am Females	0.7324	0.2676	0.6050	0.3090
	African Am Males	0.7552	0.2448	0.6064	0.2790
	Hispanic Females	0.7063	0.2937	0.5472	0.3443
	Hispanic Males	0.7359	0.2641	0.5621	0.3043
	White Females	0.7461	0.2539	0.6552	0.2908

	White Males	0.7424	0.2576	0.6350	0.2957
3	Asian Am Females	0.6182	0.3818	0.4526	0.4719
	Asian Am Males	0.5956	0.4044	0.4534	0.5070
	African Am Females	0.4721	0.5279	0.2856	0.7172
	African Am Males	0.3615	0.6385	0.2192	0.9380
	Hispanic Females	0.3502	0.6498	0.1916	0.9625
	Hispanic Males	0.4163	0.5837	0.2340	0.8243
	White Females	0.4832	0.5168	0.3166	0.6969
	White Males	0.5123	0.4877	0.3253	0.6450

Fewer than nine out of ten Hispanic males complete their first year of math and only about seventy-five percent of all Hispanic students in the study finished their second year. Note that fewer than one quarter of the Hispanic students and African American males enrolled in a fourth year of math, compared to nearly half of the Asian American students.

The calculations presented in the previous tables suggest that members of different racial and ethnic groups complete different quantities of math during high school. A variety of factors influencing a student's decision to continue or terminate the study of math have been suggested in the literature review. The hazard function can determine the likelihood that a student will terminate the study of math during time t given that he or she has continued to study math to that time. The hazard rate gives the exit rate per unit of time, not the probability of exiting during a particular time; therefore the hazard function is not restricted to be a value between zero and one. The hazard function can be written as

(1) $$h(t) = [h_0(t)]\, e^{(B1*X1 + B2*X2 + \cdots + Bn*Xn)}$$

The baseline hazard function $[h_0(t)]$ is only a function of time and does not depend on the value of other independent variables. The baseline hazard function is pictured in Figure 8. The second part of the hazard function depends on the values of the independent variables (X1,X2,...,Xn) and the coefficients (B1,B2,...,Bn).

The independent variables that will be used in this model are father's education, grades in math from grade six until the survey was administered in grade eight, high school math requirements for graduation, race, and gender. Father's education, grades in math, and math requirements are categorical variables. Dummy variables will be used for the interaction of race and gender (Hispanic males, White females, etc.). Table 5 presents the coefficients for the independent variables and their standard errors. For each of the independent variables the value is 1 if that variable describes the student and the value is 0 if it does not.

The column labeled Exp(B) presents the percentage change in the hazard function associated with the independent variable. African American males, Hispanic males, and White females have an increased hazard rate of 6.52%, 17.99%, and 2.68% respectively even when earlier performance in math, father's educational background, and school requirements are taken into account. These groups are at greater risk than the others of discontinuing coursework in mathematics. The other groups in this study have a decreased hazard function. African American females, Asian American females, Asian American males, and Hispanic females have decreased hazard rates of 16.41%, 14.13%, 27.45%, and 1.06% based on their race and gender once the other variables are taken into account. These figures are consistent with the values of the coefficients. Negative values of B are associated with decreased rates of departure (hazard rates) from mathematics and positive values of B are associated with increased hazard rates.

figure 8 - Hazard Function

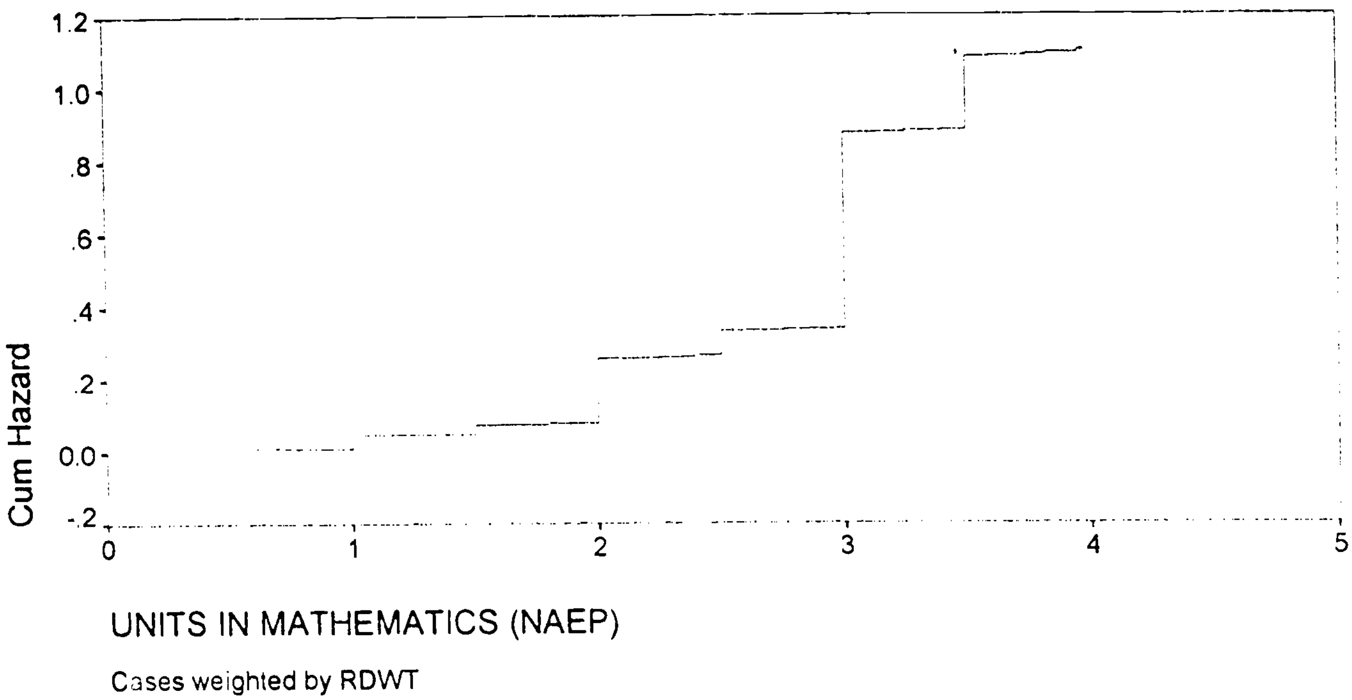


figure 9 - Hazard Function

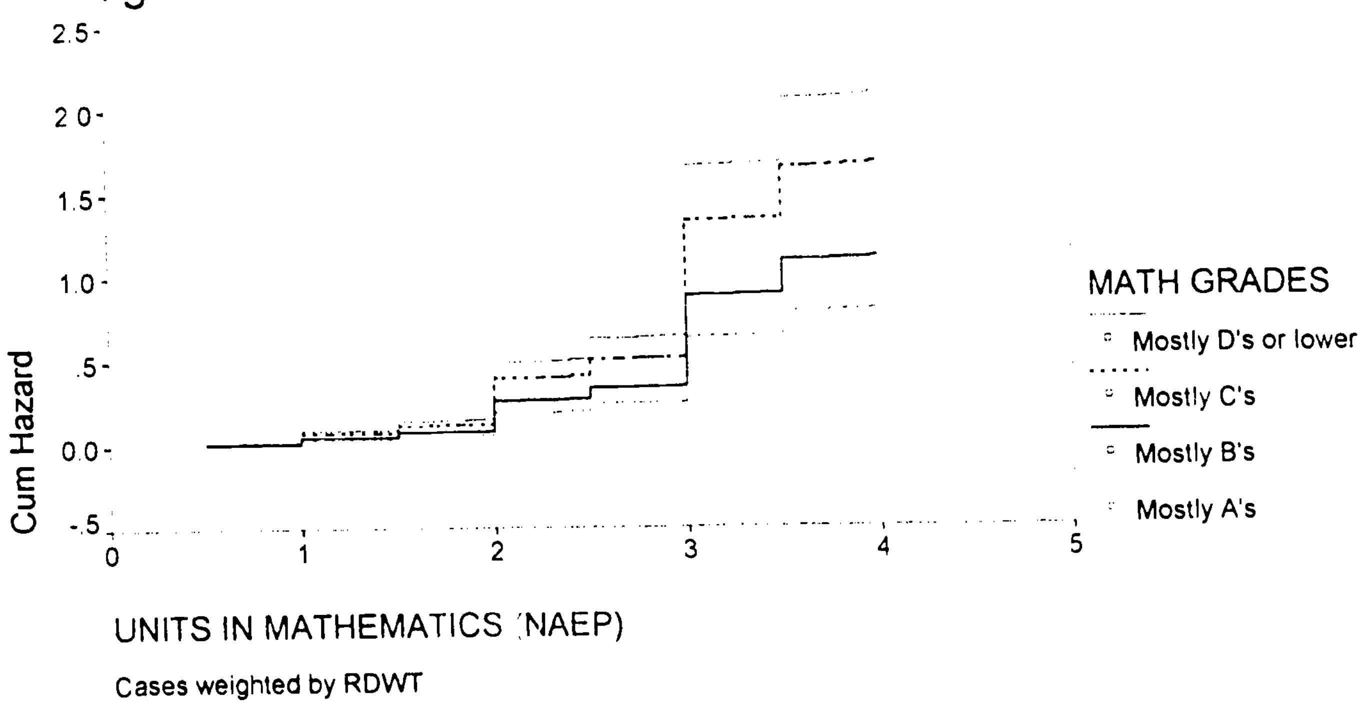


Table 5 - independent variables and coefficients based on 9771 observations

variable	coefficient	standard error	Exp(B)
African American Female	-0.1765	0.0051	0.8382
African American Male	0.0632	0.0047	1.0652
Asian American Female	-0.1524	0.0085	0.8587
Asian American Male	-0.3209	0.0088	0.7255
Hispanic Female[a]	-0.0107	0.0054	0.9894
Hispanic Male	0.1654	0.0055	1.1799
White Female	0.0265	0.0023	1.0268
Fred1 - Father did not complete high school	0.5107	0.0022	1.6665
Fred2 - Father graduated from high school	0.1780	0.0017	1.1949
Fred3 - Father completed less than 4 yr. college	0.0105	0.0020	1.0105
Fred4 - Father graduated from college	-0.2772	0.0024	0.7579
Grades1 - Mostly A's	-0.5099	0.0018	0.6006
Grades2 - Mostly B's	-0.1793	0.0016	0.8539
Grades3 - Mostly C's	0.2339	0.0019	1.2635
Req1 - Less than a year or no math required	0.3197	0.0079	1.3766
Req2 - One year of math required	0.2498	0.0063	1.2838
Req3 - Two years of math required	0.2024	0.0031	1.2244
Req4 - Three years of math required	-0.1506	0.0032	0.8602

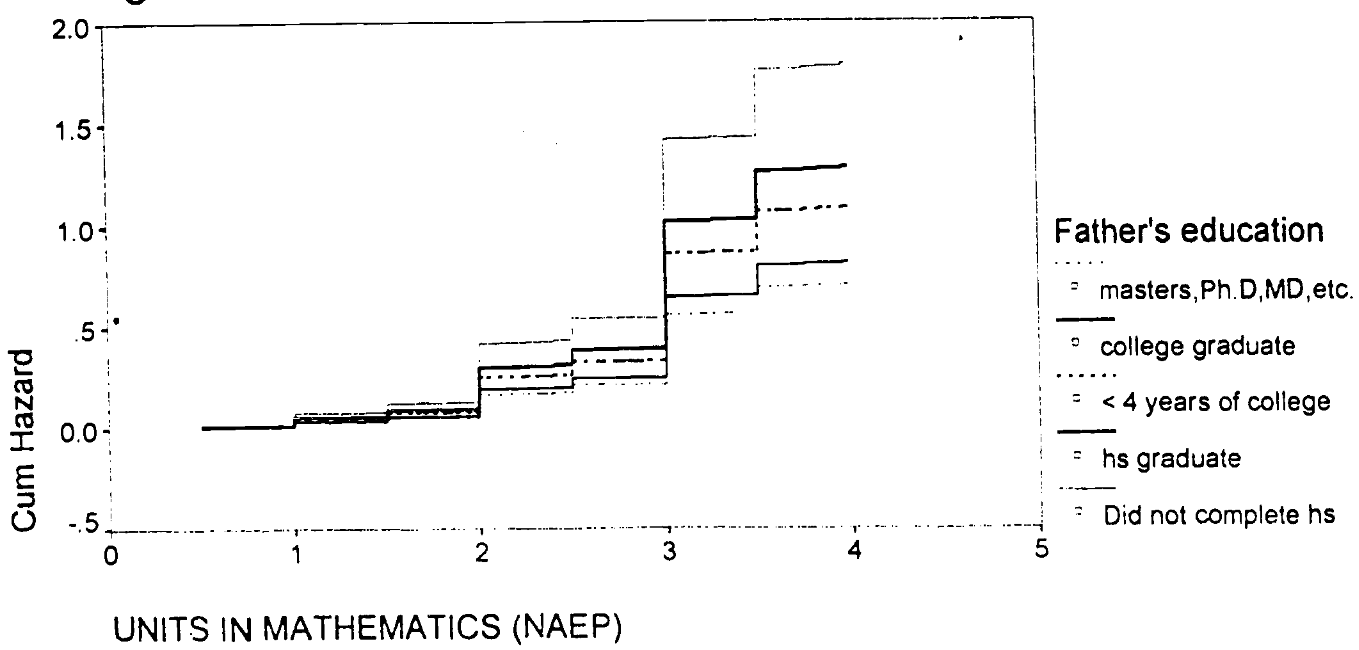
[a] significant at the 10 percent level, all other variables are significant at the 1 percent level.

The coefficients of the categorical variables father's education, grades in math, and math requirements are logical and consistent with the literature. Children of fathers with more education tend to take more math. The hazard rate for students decreases as the father's education increases. This is evidenced by the decreasing values of B as the father's level of education increases. This phenomenon can also be represented graphically by plotting the hazard functions for students based on their father's education (Figure 9). Note the increased risk of students terminating the study of mathematics if their fathers did not complete high school. The departure rate for children of college graduates and those with graduate degrees is significantly lower than for the rest of the students and there is not a significant difference between these two populations.

Similarly students who have experienced success in mathematics courses have lower departure rates than those who have not (Figure 10). This is consistent with the findings of other researchers who have concluded that past performance in mathematics is a strong predictor of future experiences in math, including enrollment patterns. Students with grades of mostly C's or lower in math courses in Junior High School are more likely to depart math at all times in high school.

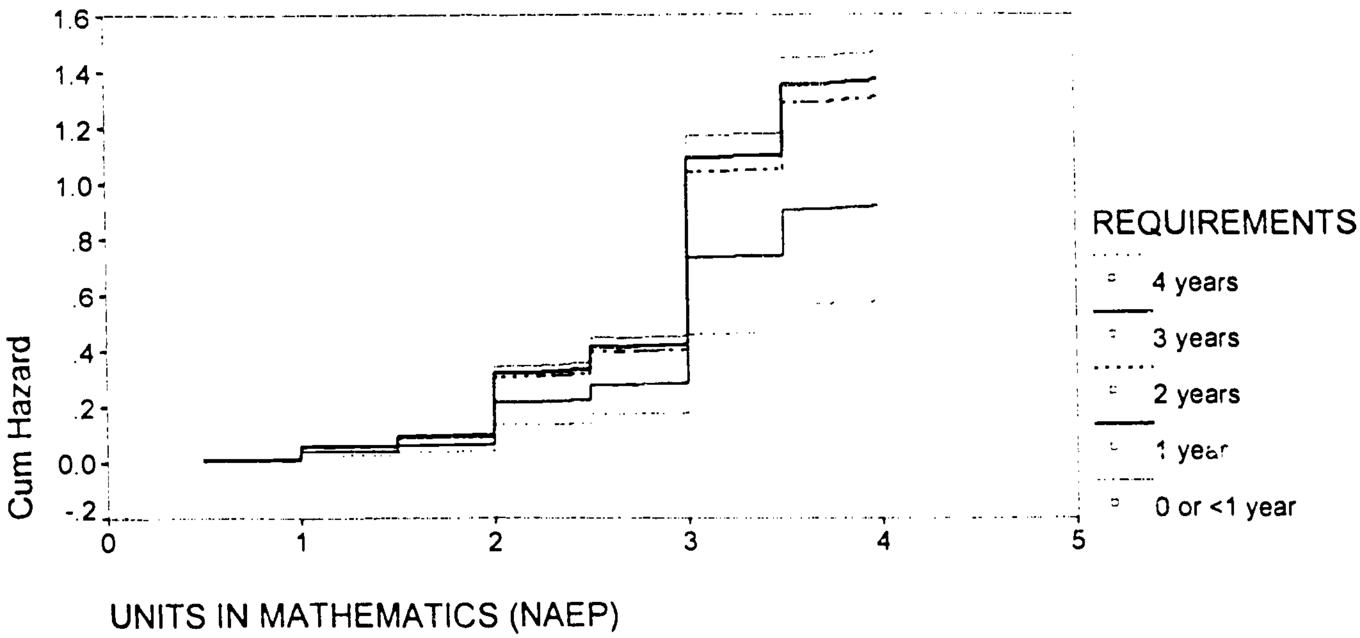
Finally, students who are required to take math classes take more math. Notice in Table 5 that the more math that is required of a student, the less likely he or she is to terminate the study of mathematics. Graduation requirements of two years of math or less are associated with an increased hazard rate (Figure 11). Students who attend schools that require students to study math for three or four years have a decreased rate of departure. This result has potential policy implications. If one believes research that suggests a student will achieve at a higher level in mathematics by enrolling in more math classes, then a means to accomplish this is to increase graduation requirements in mathematics. The other variables utilized in this study (race, sex, father's education, and earlier grades in math) are out of the control of policymakers. Those who create policy can determine graduation requirements and therefore potentially have some influence over the quantity of math a student studies. Although exposure to mathematics

figure 10 -- Hazard Function



Cases weighted by RDWT

figure 11 - Hazard Function



Cases weighted by RDWT

through more coursework does not insure greater achievement, research shows that achievement in mathematics is related to enrollment in math classes.

6. CONCLUSION

This study attempts to take the research on achievement in mathematics one step farther. It intends to include students who have been excluded from previous studies, dropouts and those who have terminated the study of math early in their high school career. Additionally it aims to determine what factors contribute to a student's decision to terminate the study of mathematics, and assess which populations are at greatest risk of terminating the study of mathematics during the various time intervals. Hispanics typically terminate the study of mathematics before African Americans. Both of these populations are at a significantly higher risk of concluding their education in mathematics during the early years of high school than Whites and Asian Americans. Father's education, previous grades in mathematics and graduation requirements are all factors that contributes to a student's decision to terminate the study of mathematics. Once father's education, past grades in mathematics, and math requirements for graduation are controlled for, African American males, Hispanic males. and White females are at a higher risk of discontinuing their study of mathematics. Prevention programs targeting these populations need to be conducted during or before their second year of math when the attrition rate can already be substantial.

This study concentrated on the quantity of math a student takes as the outcome of interest. Although the quantity of math is a significant predictor of success in mathematics, the quality of the math a student studies is also an important consideration. Quality of math can be described as the material covered in a math course or the academic rigor of a particular math course. Further study could examine students' decisions to study math and the math classes they take. Perhaps an ordered probit model could examine when students deviate from the sequence of college prep math classes and what factors contribute to this decision.

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