Effects of High School Course-Taking and Other Variables on Choice of Science and Mathematics College Majors

Jerry Trusty

Using a nationally representative sample, the effects of high school course-taking on subsequent choice of science and math majors in college were examined in the context of background variables, early academic performance, and educational attitudes and behavior in high school. Effects of course-taking on choice of science and math majors were stronger for women than for men. For women, 8th-grade math test scores positively influenced math course-taking in high school, which in turn positively influenced later choice of science and math majors. For men, completing high school physics had a significant positive effect on choice of science and math majors. These and other findings are discussed in terms of career theory and counseling and education practice.

The course-taking behavior of high school students in science and mathematics has been a particular focus of educators, researchers, and professional counselors for several years. Davenport and colleagues (1998) cited three main reasons for this focus: (a) course-taking is the major student activity in schools; (b) course-taking and achievement are closely related; and (c) it is possible to influence course-taking through educational policy, through counseling, and through advising students and parents.

Most studies on course-taking have addressed its influences on high school achievement outcomes. Using data from the ACT Assessment, McClure (1998) studied the math course-taking behavior of high school students. Students who took more college preparatory math courses also scored higher on ACT math tests. Using the SAT as an outcome variable, Brody and Benbow (1990) reported that taking rigorous science and math courses throughout the high school years resulted in higher math scores. Results from other large-scale studies (e.g., Chaney, Burgdorf, & Atash, 1997; Jones, 1987; Lee & Bryk, 1989; Lee, Croninger, & Smith, 1997) reveal similar influences of course-taking on high school achievement.

Course-taking is also related to college-level achievement. Using national data, Adelman (1999) reported that U.S. college students who completed more academically intensive course work in high school were more likely to graduate from college. For example, completing one high school mathematics course beyond the algebra II level more than doubled the likelihood that college students would complete the bachelor's degree. Adelman also found that the influences of rigorous high school course-taking on degree completion were consistently positive across socioeconomic status (SES) levels and across racial–ethnic groups. In fact, influences were stronger for African American and Hispanic students than for White students.

There has been a national trend toward more academically intensive course-taking. Data from the National Center for Education Statistics (NCES) indicated steady increases, from 1982 to 1994, in credits for all college preparatory science and math courses (National Center for Education Statistics, 2000a).

These increases were evident across genders and racial–ethnic groups. Similarly, McClure (1998) noted increases over the last decade in the number of academically stringent math courses taken. Again, these gains were evident for genders and for all major U.S. racial–ethnic groups.

High school course-taking and achievement in science and mathematics are national social and political issues. Goal 5 from the National Education Goals addresses science and math in the U.S. Of the four indicators given in Goal 5, three focus on increases in high school science and math achievement and the fourth specifies increases in the number of students—including minority students and women—graduating from college with science and math degrees (National Education Goals Panel, 1999). According to the National Education Goals Panel, there has been only a small increase in the percentage of science and math degrees awarded in the 1990s. Perhaps increases in academically intensive high school course-taking in the 1990s will result in larger increases in science and math degrees in the next decade.

Jerry Trusty, Department of Counselor Education, Counseling Psychology and Rehabilitation Services, The Pennsylvania State University. *The author thanks Chester Robinson from Texas A&M University–Commerce for his assistance in categorizing college majors.* *Correspondence concerning this article should be addressed to Jerry Trusty, 327 CEDAR Building, The Pennsylvania State University, University Park, PA 16802-3110 (e-mail: jgt3@psu.edu).*

Although the percentage of women in high-skilled college majors and occupations has increased over the last three decades (Eide, 1994; National Center for Education Statistics, 2000b), women continue to choose science and mathematics majors at a lower rate than do men (National Center for Education Statistics, 2000b). Also, the processes leading to educational choices seem to differ for women and men (Maple & Stage, 1991; Ware & Lee, 1988). For example, Trusty, Robinson, Plata, and Ng (2000) studied the effects of gender, SES, and 8th-grade academic achievement on postsecondary educational choices of U.S. students at late adolescence. Educational choices were classified as Holland types (R = realistic, I = investigative, A = artistic, S = social, E = enterprising, C = conventional; see Holland, 1997). I-type majors are science and mathematics majors. Trusty, Robinson, et al. found that men chose I-type majors more frequently than did women and that SES and gender interacted. That is, positive effects of SES on choice of I-type majors were stronger for women than for men. Also, gender and early achievement interacted in that different types of early achievement influenced women's and men's educational choices in different ways. Across all types of postsecondary majors, early math achievement had a stronger influence on men's choices, whereas reading achievement had a stronger influence on women's choices.

This finding is consistent with Eccles's (1994) model of achievement-related choices. Eccles contended that women and men differ in their *subjective task values*, with women valuing language-related skills and tasks more and men valuing mathematics-related skills and tasks more. According to Eccles, this difference explains the lower frequency of women entering science and math fields. This difference may also explain the higher frequency of advanced mathematics courses taken in high school by boys as compared with girls (see Davenport et al., 1998). However, the National Center for Education Statistics (2000a) found that differences between genders in advanced math course-taking lessened in the 1990s. Regarding high school science courses, girls were less likely than boys were to take physics, but girls were more likely than boys were to take biology and chemistry.

Course-taking in high school also differs for racial–ethnic groups. Davenport et al. (1998) found that the more rigorous math courses were taken most frequently by Asians, with Whites, Hispanics, and African Americans following respectively. The National Center for Education Statistics (2000a) reported a similar racial–ethnic pattern for advanced science courses. Differential course-taking patterns among racial–ethnic groups, in fact, seem to reinforce inequity in short- and long-term academic achievement. For example, Lee et al. (1997) found that in schools with few options other than rigorous academic course work, achievement differences among racial–ethnic groups and SES groups were smaller. Davenport et al. (1998) concluded that racial–ethnic discrepancies in high school course-taking translate into discrepancies in postsecondary achievement and participation in science and math fields.

There is evidence that race–ethnicity and SES have an interaction effect on choice of science and math majors. Trusty, Ng, and Plata (2000) studied the interactions of gender, race–ethnicity, and SES on choice of all types of postsecondary fields of study. They found that Asian/Pacific Islander men chose science and math majors with high frequency regardless of SES level. With increases in SES, Hispanics and African Americans increased in frequency of choice of science and math majors. White men were comparatively low in choice of science and math majors. Effects of race–ethnicity were weaker for women.

Students' school-related attitudes also seem to influence choice of science and mathematics majors. Maple and Stage (1991) found a positive effect for math attitudes. Ware and Lee (1988) reported that math attitudes and general attitudes about high school had positive effects on choice of science majors. Trusty and Ng (2000) studied the effects of students' self-perceptions of math ability and English ability on the full range of postsecondary educational choices. They found that self-perceptions of math ability had relatively strong effects on choices, with stronger effects for men. Eccles and Jacobs (1986) found that self-perceptions of math ability influenced math achievement and math course-taking plans.

There have been many research studies on choice of science and mathematics college majors and occupations (e.g., Betz & Hackett, 1983; Eccles, 1994; Hackett, 1985; Lent, Brown, & Hackett, 1994; Maple & Stage, 1991; Oakes, 1990; Ware & Lee, 1988). However, few researchers have focused on the effects of high school course-taking on choice of these majors or fields. Hackett (1985) developed a path model of choice of science and math majors. Hackett found that the number of years of high school math taken had a positive effect on choice of these majors. Mathematics self-efficacy also had a positive direct effect on choice of major. The validity of this study, however, is limited because the sample was a relatively small, cross-sectional convenience sample. Therefore, temporal causal sequence was inferred, and the effects of self-efficacy, for example, were likely spuriously strong due to the cross-sectional design. In addition, Hackett did not develop separate models for genders, and the academic intensity of math courses was not considered.

There have been two large-scale, longitudinal studies of the effects of course-taking on choice of science and math majors. Maple and Stage (1991) used High School & Beyond (HS&B) national data to study the influences of several variables, including course-taking, on choice of science and mathematics majors. Maple and Stage found that students who took more science and math courses in high school were significantly more likely to choose science and math majors in college. Maple and Stage also reported that early academic performance had effects on students' choices of high school program, high school grades, and students' plans to pursue science and math majors. Ware and Lee (1988), in a similar study using HS&B data, found that the effect of the number of math courses taken was significant for women, whereas the effect of the number of science courses taken was significant for men. In the two aforementioned studies, however, researchers did not effectively account for the academic rigor of courses taken or for the separate effects of particular courses.

PURPOSE AND THEORETICAL BASES

The purpose of the present study was to examine the effects of taking particular academically intensive science and mathematics high school courses on choice of science and mathematics majors, versus other majors, in college. Effects of course-taking were studied in the context of background variables, early academic performance, and educational attitudes and behaviors. Background variables were SES and race–ethnicity. Academic performance variables included 8th-grade science and math scores. Educational attitudes and behavior variables were (a) general educational attitudes, (b) mathematics self-perceptions, (c) the amount of time spent on homework outside school, and (d) the amount of time spent using personal computers. High school courses included in the study were (a) biology, (b) chemistry, (c) physics, (d) algebra II, (e) geometry, (f) trigonometry, (g) pre-calculus, and (h) calculus. Because gender interactions have been identified in previous research, separate analyses were performed for gender. The Race-Ethnicity × SES interaction, identified in the literature, was investigated through post hoc analyses. Knowing the relative effects of course-taking and other variables on later choice of a science and math major will be useful information for counselors, educators, and parents. Results should also have implications for career development theory.

All theories of career development and career choice emphasize the influences of abilities, achievements, and skills. However, Krumboltz's (1979) theory focuses strongly on how skills develop through learning experiences such as course-taking. Krumboltz (1979) developed a social learning theory of career decision making. According to Krumboltz's (1979) theoretical formulations, individuals and environments interact in producing educational and occupational choices. Learning experiences are axiomatic in this process, and learning experiences come in many forms, including high school courses, extracurricular activities, and leisure activities. Learning experiences lead to *self-observation generalizations, task approach skills,* and *actions*. Self-observation generalizations are generalized perceptions of performance in specific areas. Self-judgments, preferences and interests, and values are all self-observation generalizations. If a person has a positive self-observation generalization in a particular area, the person is likely to seek more learning experiences in that area. Task approach skills are the skills that individuals use to cope with, interpret, and adapt to their environments. Self-observation generalizations and skills lead to actions. These actions are the career-related choices that individuals make throughout life. Course-taking in high school and choice of major in college are career-related actions. Krumboltz (1979) posited,

> It is the sequential cumulative effects of numerous learning experiences affected by various environmental circumstances and the individual's cognitive and emotional reactions to these learning experiences and circumstances that cause a person to make a decision to enroll in a certain educational program. (p. 37)

In Krumboltz's framework, course-taking is conceptualized as both learning experiences and career-related actions. This conceptualization is consistent with several research studies (e.g., Davenport et al., 1998; Eccles, 1994; Maple & Stage, 1991; Ware & Lee, 1988).

Eccles's (1994) research and theory address the differing processes of college major choices for women and men. If women value language-related skills and tasks more and men value math-related skills and tasks more, then it would be expected that the present study would reveal stronger effects of science and math scores for men. Also, math self-perceptions should have stronger effects on choice of science and math majors for men than for women.

METHOD

Participants

Participants were 2,956 women and 2,747 men who were a subsample from the transcript panel sample of the National Education Longitudinal Study of 1988–94: Data Files and Electronic Codebook System (NELS:88; 1996). NELS:88 began in 1988 and is a continuing study. The analysis sample was a nationally representative sample of U.S. students who attended college soon after high school. Of the participants, approximately 26% were from urban areas, 47% were from suburban areas, and 27% were from rural areas. Regarding geographic regions, roughly 24% were from the Northeast, 24% were from the Midwest, 34% were from the South, and about 18% were from the West. Approximately 5% were Asian/Pacific Islander Americans, 8% were Hispanic Americans, 12% were African Americans, 74% were White Americans, and about 1% were Native Americans.

Data used were from several NELS:88 sources spanning 6 years: (a) the parent questionnaire, student questionnaire, and academic tests administered when students were in the 8th grade (Base Year); (b) student questionnaires administered at the 10th-grade level (First Follow-Up) and 12th-grade level (Second Follow-Up); (c) high school transcript data; and (d) the student questionnaire completed 2 years after high school graduation (Third Follow-Up). In arriving at an analysis sample, several steps were accomplished. First, only participants who had attended a postsecondary institution for at least 2 months were potential sample members. Of this group, those who did not have a specific college major field of study were excluded. Of the group remaining, participants who did not expect to receive at least a bachelor's degree were excluded. Therefore, the sample represents U.S. college students who (a) attended high school in the U.S., (b) were working toward a bachelor's degree within 2 years after high school, and (c) had a specific college major.

The National Center for Education Statistics (NCES) calculated various sampling weights for use in analysis of NELS:88 data. These weights redistribute the sample to represent the particular population, and they help control for nonresponse bias. NCES calculated a transcript weight for use with 12th-grade transcript data, and this weight was used in all analyses performed. Ten men did not have data on the race–ethnicity variable, and they were excluded. There was some nonresponse on other variables (5% to 11%) used in the study, and for these missing values, the mean was imputed.

For the NELS:88, a two-stage sampling design was used. That is, U.S. schools were first sampled, and then students within schools were sampled. Because within-schools groups are likely to be more homogeneous than are groups across schools, this two-stage sampling process produces sample variances that are smaller than population variances. To correct for spuriously small variances, NCES calculated design effects. In the current study, design effects were used to account for the NELS:88 complex sampling design. This procedure is described in detail in the Data Analysis section.

Variables

The dependent variable was choice of a science and math major versus other majors. To develop this variable, I used a NELS:88 item on which respondents indicated 1 of 112 postsecondary majors in which they were engaged. With the help of a research colleague, I used the Educational Opportunities Finder of the Self-Directed Search (Rosen, Holmberg, & Holland, 1997) and a study of college-major classification by Harrington, Feller, and O'Shea (1993) to classify majors into the two groups. Science and math majors are I-type majors as described by Holland (1966, 1997). Several majors were clearly science and mathematics. Other majors have been inconsistently categorized by instruments and the literature as science and math or non-science-and-math majors. In classifying these majors, we followed the judgments of people working in particular fields more than judgments of other groups (see Harrington et al., 1993). Those variably categorized majors were classified for the present study as follows: (a) majors in psychology, agriculture, and nursing were classified as non-science-and-mathematics, and (b) computer science was classified as a science and math major. Working independently, my research colleague and I agreed on all categorizations. Frequently chosen science and math majors were engineering, computer science, biology, and liberal studies. Choice of a science and math major was coded as 1, and choice of a non-science-and-math major was coded as 0.

Background variables. The SES variable was a composite variable developed by NCES and included family income, parents' educational levels, and occupational prestige. SES was expressed in *z* scores. The race–ethnicity variable included the five major U.S. racial–ethnic groups: Asian/Pacific Islanders, Hispanics, African Americans, Whites, and Native Americans.

Early academic performance. Two NELS:88 academic test scores, science and mathematics, were used from Base-Year (8th-grade) data. Eighth-grade test scores were used because the particular science and mathematics courses that students took after the 8th grade became increasingly varied, and therefore a single test for all students would not be appropriate. In NELS:88, academic tests administered after the 8th grade varied in difficulty depending on students' prior performance. Items on the science and math tests ranged in difficulty from simple calculations and recall to application of complex concepts in multistep problems. For the purpose of analyses, 8th-grade test scores were expressed as *z* scores.

High school attitudes and behavior. I developed the educational attitudes variable through factor analysis. Several NELS:88 Second Follow-Up (12th-grade) items assessed students' general attitudes about various aspects of education. One factor comprising four items was selected. The items assessed the perceived importance of attending classes, studying, getting good grades, and continuing academics past high school. The four items loaded above .75 in the rotated factor matrix. The internal consistency reliability coefficient (alpha) for the current sample was .84.

Mathematics self-perceptions were quantified by one item from the NELS:88 First Follow-Up Questionnaire completed when students were in the 10th grade. Students responded to the statement "Math is one of my best subjects." Respondents could indicate one of six answers: false, mostly false, more false than true, more true than false, mostly true, true. This item elicits an intra-individual comparison of various skills relative to mathematics. According to Krumboltz (1979), comparative self-judgments of this type lead to choices. Trusty and Ng (2000) found relatively strong effects of this item on choice of the full range of postsecondary majors.

Two single NELS:88 items were used in this study as educational behavior variables. The homework variable quantified the amount of time seniors spent on homework out of school, ranging from *none* to *over 20 hours per week*. The computer use variable was also assessed in the 12th grade. Students indicated the frequency of use of personal computers on a 4-point scale, ranging from *never/rarely* to *almost every day*. All the high school educational attitudes and behavior variables were converted to *z* scores for analysis.

Course-taking behavior. Eight variables from NELS:88 transcript data were used to indicate high school science and mathematics course-taking behavior. Courses included were biology, chemistry, physics, algebra II, geometry, trigonometry, pre-calculus, and calculus. The scale was consistent with that used by the National Assessment of Educational Progress (NAEP; see Ingels et al., 1994), and quantified high school units. Most students on most of the eight variables had either none, one half, or one unit in the above courses. However, some values were expressed in other fractions of units, and some students had more than one unit in these courses. These variables were expressed in their original values, high school credits.

Data Analysis

Although courses such as physics and calculus are usually taken in the 12th grade, it was assumed that the temporal sequence of courses taken across the high school years was not consistent across participants. Therefore, the temporal sequence of course-taking and other independent variables in the models, namely the high school educational attitudes and behavior variables, was inconsistent across participants. The temporal sequence between the independent variables and the dependent variable was clear and consistent, and the temporal sequence among 8th-grade variables and high school variables was consistent. Because of lack of temporal sequence within all the independent variables, and following the lead of previous studies (Maple & Stage, 1991; Ware & Lee, 1988), I placed independent variables into two major groups: (a) course-taking variables and (b) other variables. The major focus of this study was on course-taking; therefore, other variables were first in a hierarchical analysis and course-taking variables were next. This organization and sequence of independent variables is consistent with earlier models of Maple and Stage and Ware and Lee. This arrangement yields more information on course-taking by allowing examination of the influences of other independent variables on course-taking as well as the direct influences of course-taking on choice of science and math majors while controlling for other variables. That is, course-taking was examined as an outcome and an influence, and, conceptually, taking courses was treated as both career-related actions and learning experiences (see Krumboltz, 1979).

Data for women and men were analyzed separately. Choice of a science and math major versus choice of some other major was the dependent variable. In each analysis, two models were developed. Model 1 included background variables, academic performance variables, and high school educational attitudes and behavior variables only. Model 2 (the full model) included the aforementioned variables and course-taking variables. Comparison of the two models allowed examination of indirect effects (through course-taking) of background variables, academic performance variables, and educational attitudes and behavior variables. Comparison of the two models also revealed the increment of variability explained by course-taking, above and beyond the effects of other pertinent variables.

Data were analyzed through logistic regression. Logistic regression is the appropriate form of regression analysis when the dependent variable is dichotomous (Agresti, 1990; Menard, 1995), as in the present study. Logistic regression coefficients are the natural log odds of one outcome versus the other outcome for every one-unit increase of the particular independent variable. A log odds of 0 signifies no relationship of an independent variable to the dependent variable. A positive log odds indicates that an increase in the independent variable is associated with an increase in the likelihood of the outcome, and a negative log odds indicates that an increase in the independent variable is associated with a decrease in the likelihood of the outcome. Log odds may be transferred into odds, and odds are more straightforward in interpretation. An odds is the probability of the occurrence of an event divided by the probability of the event not occurring. A log odds of 0 is equivalent to an odds of 1 (no relationship between the independent and dependent variable). Negative log odds produce odds less than 1, and positive log odds transfer to odds greater than 1.

SES, test scores, and the educational attitudes and behavior variables were expressed in *z* scores. Therefore, logistic regression coefficients for these variables are standardized logistic regression coefficients, and odds for these variables reflect the change in the odds on the dependent variable for every 1 standard deviation increase in the independent variable. For the race–ethnicity variable, deviation contrasts were used (see Norusis, 1994). With deviation contrasts, the log odds and odds of particular racial–ethnic groups are compared with all racial–ethnic groups taken together.

The course-taking behavior variables were expressed in high school Carnegie units. Therefore, these logistic regression coefficients and odds indicate the increase or decrease in the odds on the dependent variable for every one-high school unit increase in the particular course.

Regarding sampling design effects, the mean root design effect for the NELS:88 Third Follow-Up entire sample was 1.7. I studied a select group from the entire sample, and analyses were performed separately by gender groups. Design effects are smaller for sample subgroups (see Ingels et al., 1994). Therefore, I used a root sampling design effect of 1.5. That is, the standard error of each logistic regression coefficient was multiplied by 1.5 before performing statistical significance tests. This procedure seemed to allow statistical conservatism without overinflating the chance of Type II error.

Because there is evidence of a Race–Ethnicity × SES interaction, post hoc models were developed to test and examine this possible interaction. The interaction was tested by first entering the two single variables, followed by the interaction term. Coding of the race–ethnicity variable was changed to indicator coding (dummy coding) to test this interaction.

RESULTS

The percentages of women and men in the sample who completed at least one unit of high school credit in the various science and math courses are presented in Table 1. More men than women completed one or more units in physics. Slightly more women than men completed at least one credit in algebra II. For other courses, percentages were very similar for women and men.

Logistic Regression Models for Women

Slightly over 22% of female participants were in a science and math major, and the other 78% were in some other major. The log odds *(B)*, partial correlation coefficients, odds, and zero-order logistic correlation coefficients *(r)* for women are presented in Table 2. Regarding background variables,

TABLE 1

Percentages of Women and Men Who Completed One or More Units of Advanced Science and Math Courses in High School

Course	% Women	% Men
Biology	92	91
Chemistry	68	67
Physics	27	39
Algebra II	61	56
Geometry	95	94
Trigonometry	15	17
Pre-calculus	19	18
Calculus	13	15

SES was not significant in either model for women. Race–ethnicity differences, taken as a whole, were significant in both models ($p < .001$), but because of relatively high standard errors, no single racial–ethnic group differed significantly from all racial–ethnic groups taken together. Given all variables in the models, African American women were most likely to be in science and math majors, and White and Native American women were least likely to be in science and math majors. Hispanic and Asian/Pacific Islander women differed little from all racial–ethnic groups. Note that the partial correlations were higher than the zero-order correlations, indicating that variables other than race–ethnicity were largely responsible for these effects. By generating additional models excluding variables, I determined that the presence of science and math scores in models strengthened the effects of race–ethnicity.

Regarding early academic performance, the effects of science scores were positive in both models, but these effects were not significant. The effect of mathematics scores in Model 1 was significant. A 1 standard deviation increase in math scores resulted in a 30% increase in the odds of choosing a science and math major, given all variables in Model 1. However, in Model 2 (the model including course-taking variables), the effect of math scores was not significant. This indicates that the effect of math scores was largely indirect, through course-taking behavior. To determine the particular courses on which the effect of math scores impinged, I generated additional models, alternatively excluding course-taking variables. As a result, it was found that the effect of math scores was indirect through the most advanced math courses, namely, trigonometry, pre-calculus, and calculus.

For high school educational attitudes and behavior variables, the effect of school attitudes was significant and

TABLE 2

Logistic Regression Models of Effects on Choice of Science and Math Majors for Women (N = 2,956)

	Model 1			Model 2			
Independent Variable	*B*	Partial	Odds	*B*	Partial	Odds	*r*[a]
Background Variables							
SES	.04	.00	1.04	−.04	.00	0.97	.02
Race–Ethnicity[b]		.08***			.06***		.02
Asian/Pacific Islander	.05	.00	1.05	−.07	.00	0.93	.00
Hispanic	.15	.00	1.16	.20	.00	1.22	.00
African American	.42	.03	1.51	.37	.03	1.44	.01
White	−.30	−.02	0.74	−.23	.00	0.80	.00
Native American	−.32		0.73	−.27		0.76	
Early academic performance							
Science scores	.15	.03	1.16	.13	.03	1.14	.11
Math scores	.26**	.06	1.30	.07	.00	1.07	.12
High school educational attitudes and behavior							
Attitudes	−.18**	−.06	0.83	−.22**	−.08	0.80	−.05
Math self-perceptions	.03	.00	1.04	−.05	.00	0.96	.05
Homework	.16*	.06	1.18	.10	.03	1.11	.07
Computer use	.01	.00	1.01	.03	.00	1.03	.00
Course-taking behavior							
Biology				.21	.04	1.24	.06
Chemistry				.15	.00	1.16	.09
Physics				.15	.00	1.17	.11
Algebra II				−.13	.00	0.88	.00
Geometry				−.50**	−.07	0.60	.00
Trigonometry				.49**	.07	1.64	.12
Pre-calculus				.39*	.05	1.48	.12
Calculus				.76***	.10	2.14	.18

Note. Choice of a science and math major was coded as 1; choice of other majors was coded as 0. Nagelkerke R^2 in Model 1 = .054, in Model 2 = .108. A root design effect of 1.5 was multiplied by each standard error in calculating significance of logistic regression coefficients.
[a]The *r* column indicates the zero-order logistic relationship of the particular independent variable to choice or non-choice of a science and math major. [b]Race–Ethnicity was deviation-coded. The *B* for the Native American comparison group was derived as the negative sum of coefficients for other groups. Odds were calculated from the *B*s.
*$p < .05$. **$p < .01$. ***$p < .001$.

negative in both models. This seems to indicate that more positive attitudes about school resulted in a reduced likelihood of choosing a science and math major. Note that the zero-order coefficient for educational attitudes was negative but weaker than the partial coefficients. Therefore, educational attitudes took on a suppressor function in both models. Suppressor variables suppress error for other variables in a regression model. When a variable's zero-order correlation is weaker than or has an opposite sign than its partial correlation, it is likely to be a suppressor (Pedhazur, 1982). Suppressor variables do not represent singular effects; rather, observed effects are functions of other related variables in the equation. By generating additional models excluding variables, I determined that the educational attitudes variable suppressed error for SES, homework, and course-taking variables. The amount of time spent on homework outside school had a significant positive effect in Model 1 only, indicating that this effect was partially indirect through course-taking. The effects of math self-perceptions and computer use were weak in both models for women.

Regarding the effects of course-taking behavior for women, effects of biology, chemistry, and physics course-taking were positive but nonsignificant. Geometry had a significant negative effect. However, this was a suppressor function. Note in Table 2 that the zero-order coefficient was 0, and the partial coefficient was negative. Therefore, this effect was a function of other variables in the equation. Through generating models excluding variables, it was determined that geometry units suppressed error for other course work variables and for science and math scores. The effects of taking trigonometry, pre-calculus, and calculus were significant and positive for women. Taking one unit in trigonometry resulted in a 64% greater likelihood of later choosing a science and mathematics major as opposed to some other major. Taking one unit in pre-calculus produced a 48% increase in the odds of choosing a science and math major. A one-unit increase in calculus course-taking resulted in the odds more than doubling that women would later choose science and math majors. Note that these effects were significant while controlling for influences of background variables, early academic performance, and educational attitudes and behavior.

Logistic Regression Models for Men

Slightly more than 36% of male participants were in a science and math major. The log odds *(B)*, partial correlation coefficients, odds, and zero-order logistic correlation coefficients *(r)* for men are presented in Table 3. Regarding background

TABLE 3

Logistic Regression Models of Effects on Choice of Science and Math Majors for Men ($N = 2{,}747$)

	Model 1			Model 2			
Independent Variable	***B***	**Partial**	**Odds**	***B***	**Partial**	**Odds**	***r*** [a]
Background Variables							
SES	−.04	.00	0.96	−.07	.00	0.93	.00
Race–Ethnicity[b]		.09***			.09***		.07
Asian/Pacific Islander	.39	.03	1.48	.33	.02	1.39	.05
Hispanic	−.17	.00	0.84	−.15	.00	0.86	.00
African American	.20	.00	1.22	.23	.01	1.26	.00
White	−.43*	−.05	0.65	−.41*	−.05	0.66	−.03
Native American	.01		1.01	.00		1.00	
Early academic performance							
Science scores	.32***	.09	1.38	.31***	.09	1.37	.13
Math scores	−.05	.00	0.96	−.10	−.01	0.90	.11
High school educational attitudes and behavior							
Attitudes	.07	.01	1.07	.07	.01	1.07	.05
Math self-perceptions	.40***	.13	1.49	.36***	.12	1.43	.16
Homework	.06	.00	1.06	.04	.00	1.04	.07
Computer use	.20***	.08	1.22	.19**	.08	1.21	.11
Course-taking behavior							
Biology				−.06	.00	0.95	.00
Chemistry				.05	.00	1.06	.08
Physics				.33*	.06	1.39	.14
Algebra II				.07	.00	1.07	.03
Geometry				−.37*	−.05	0.69	.00
Trigonometry				.27	.03	1.32	.08
Pre-calculus				−.06	.00	0.94	.05
Calculus				.07	.00	1.07	.10

Note. Choice of a science and math major was coded as 1; choice of other majors was coded as 0. Nagelkerke R^2 in Model 1 = .106, Model 2 = .123. A root design effect of 1.5 was multiplied by each standard error in calculating significance of logistic regression coefficients.
[a]The *r* column indicates the zero-order logistic relationship of the particular independent variable to choice or non-choice of a science and math major. [b]Race–Ethnicity was deviation-coded. The *B* for the Native American comparison group was derived as the negative sum of coefficients for other groups. Odds were calculated from the *B*s.
*$p < .05$. **$p < .01$. ***$p < .001$.

variables, SES was not significant in either model for men. Race–ethnicity, as a whole, was significant for men ($p < .001$). As in the women's models, standard errors were high for particular racial–ethnic groups. The only significant effect for a single racial–ethnic group was the effect for Whites. Whites were only 66% as likely as all racial–ethnic groups—taken together—to be in a science and math major, given all variables in the equation. Stated in the inverse, Whites were 51% more likely than all racial–ethnic groups not to choose a science and mathematics major. Note that the partial coefficient for the race–ethnicity variable was slightly stronger than the zero-order (r) coefficient, indicating that other variables in the equation served to strengthen this effect somewhat. By generating models excluding variables, it was evident that 8th-grade science and math scores and math self-perceptions strengthened the race–ethnicity effect. However, as evidenced by the zero-order logistic coefficients for the racial–ethnic groups, White men were slightly less likely than were other groups to be in a science and math major. Asian/Pacific Islander men were most likely to choose science and math majors.

Regarding the academic performance variables, effects of science scores were significant in both models. While controlling for effects of all other variables, a 1 standard deviation increase in men's 8th-grade science scores resulted in a 37% increase in the odds of being in a science and math major 6 years later. The effect of science scores was strong in both models, indicating that the effect was almost entirely direct and not indirect through course-taking. The effect of math scores was weak for men. However, this observed lack of effect was not genuine. That is, men's 8th-grade science and math scores were strongly related to one another ($r = .71$), and by generating models without science scores, it was evident that science scores dominated the effects of math scores on choice of science and math majors. Also, math self-perceptions eroded a portion of the effect of math scores.

Regarding high school educational attitudes and behavior variables, the effect of math self-perceptions was strong and positive in both models. The beta and partial coefficient had only a slight decrease from Model 1 to Model 2, indicating that the effect was largely direct. While accounting for the effects of all other variables (Model 2), a 1 standard deviation increase in positive comparative math self-perceptions resulted in a 43% greater likelihood of men choosing a science and mathematics major. Computer use had a significant positive effect in both models, indicating that this effect was mostly direct. In the full model (Model 2), a 1 standard deviation increase in computer use resulted in a 21% increase in the odds of choosing a science and math major as opposed to some other major. This effect was independent of effects of academic performance, course-taking behavior, and other variables.

Regarding the effects of course-taking for men, effects of biology and chemistry were nonsignificant. The effect of taking physics was significant and positive. Taking one unit in physics resulted in a 39% greater likelihood of later choosing a science and math major, given all variables in the full model. The effect of geometry was negative and significant. However, similar to the geometry effect in the model for women, this was a suppressor effect. Geometry suppressed error for other course-taking variables. For men, the bivariate relationships for the more rigorous math courses (i.e., trigonometry, pre-calculus, calculus) were positive and relatively weak. The effects of taking these courses were nonsignificant in the full logistic regression model. By generating models excluding variables, it was obvious that effects of science and math test scores and math self-perceptions dominated the weak positive effects of the more rigorous math courses.

Post Hoc Analyses of Race–Ethnicity × SES Interaction

The interaction of Race–Ethnicity SES was significant for men, $p = .010$, but nonsignificant for women, $p = .682$. I examined the nature of the interaction for men by splitting them into SES categories and investigating the varying influences of race–ethnicity across SES levels. At lower levels of SES, Asian/Pacific Islanders were highest in choice of science and math majors; African Americans were around the average; and Hispanics, Whites, and Native Americans were relatively low in choice of science and math majors. At higher levels of SES, Asian/Pacific Islanders, Hispanics, and African Americans were relatively high in choice of science and math majors; and Whites and Native Americans were relatively low. Stated differently, increases in SES resulted in large increases in choice of science and math majors for Hispanic men and moderate increases for African American men. Regardless of SES, Asian/Pacific Islander men were comparatively high and White and Native American men were comparatively low in choice of science and math majors.

DISCUSSION AND IMPLICATIONS

Results of this study generalize to U.S. college students who attended high school in the U.S. and had an academic major. All students in the sample expected to earn at least a bachelor's degree. I examined the effects of background variables, 8th-grade science and math performance, educational attitudes and behavior in high school, and academically intensive course-taking in high school on choice of a science and math major versus some other college major.

Course-taking in high school did influence choice of science and math majors, and these influences were different for women and men. For women, taking the most academically intensive math courses—trigonometry, pre-calculus, calculus—had positive effects on choice of science and math majors. The effect of taking calculus was particularly strong for women. Taking one high school unit in calculus more than doubled the odds of later choosing a science and math major. These effects were independent of background variables, of early science and math performance, and of educational attitudes and behaviors. For men, the effects of course-taking were much weaker. Only physics had a significant positive effect on choice of science and math majors, and this effect was not particularly strong. In models for women and men, the effect of units in geometry was a suppressor effect. That is, geometry suppressed error for other course-taking variables.

Thus, there were two general differences between women and men in the effects of course-taking. First, effects were much stronger for women than for men. Second, the only significant effects for women were from the three most rigorous math courses, whereas for men, the only significant effect was from one science course, physics. This second general difference is consistent with earlier findings of Ware and Lee (1988). Using HS&B national data from the 1980s, Ware and Lee found that the number of math courses taken had the strongest effect on choice of science and math majors for women, whereas for men, the number of science courses taken had the strongest effect.

There are several possible reasons for these observed gender differences in the effects of course-taking. One possibility is that variables other than course-taking variables could have dampened the effects for men more than for women, therefore resulting in weaker observed effects for men. Also, other variables could have variably weakened or strengthened effects of math or science courses for women or men. However, the results do not support these possibilities. In examining the bivariate (zero-order) relationships between courses taken and choice of a science and math major, the three most advanced math courses—trigonometry, pre-calculus, calculus—had the strongest relationships for women, consistent with the full logistic regression model. There was some weakening of science course effects in the full model for women. For men, the strongest bivariate relationship was from physics, and bivariate relationships for courses taken were weaker for men than for women. This was also consistent with the full logistic regression model. The legitimacy of findings is also strengthened by the fact that course-taking variability of women differed little from the course-taking variability of men.

Therefore, it seems that there are genuine gender differences in the effects of course-taking. Mathematics learning experiences seem to influence choice of science and math majors more for women, and science learning experiences seem to influence choice more for men. I found a similar gender-based pattern in the effects of early (8th-grade) academic performance. Math scores had a stronger effect for women, and science scores had a stronger effect for men. However, there were gender differences in the indirect effects of these variables. For women, early math performance positively affected course-taking in math, which in turn positively affected choice of science and math majors. That is, early math performance had an indirect effect—via course-taking—on choice of major for women. For men, the effect of early science performance was almost entirely a direct effect on choice, and there was little indirect effect through course-taking. For men, 8th-grade science scores dominated the effect of math scores, so it would be incorrect to assume that the strength of effect on choice of science and math majors lies only in early science performance. Thus, both science and math performance seem important.

In the existing social, political, and economic environment, there is effort toward increasing the number of young people, and especially women, in science and mathematics fields (see National Education Goals Panel, 1999). The current results imply that for women, higher early math performance leads to taking more rigorous math courses in high school, which in turn leads to a substantial increase in the likelihood of women choosing a science and math major. The inverse is also implied. That is, lower early mathematics performance leads to not taking more stringent math courses in high school, which in turn leads to choosing some major other than a science and math major. Low mathematics achievement in high school and earlier, therefore, may serve to block women from science and math fields. Perhaps a constrained mathematics curriculum—a curriculum limited to rigorous course work—would steer more women toward science and math fields (see Lee & Bryk, 1989; Lee et al., 1997). However, sound early preparation in mathematics should precede a rigorous high school curriculum. It would be naïve for counselors and educators to assume that more stringent math course work in high school would be appropriate for all students.

Two other findings for men stand in stark contrast to findings for women. First, men's intra-individual comparative perceptions of their math skills (math self-perceptions) had a relatively strong effect on choice of a science and math major. Second, the degree of computer use in high school had a positive effect for men. Both of these effects were almost entirely direct, and not indirect through course-taking. Neither of these effects was present for women. Therefore, Krumboltz's (1979) theory of career decision making seems to hold better for men than for women regarding self-observation generalizations, and it seems to hold better for women than for men regarding learning experiences in the form of high school course-taking. Krumboltz's theory seems to hold for men regarding learning experiences in the form of computer use.

Findings regarding math self-perceptions are consistent with Eccles's (1994) theory. That is, if men value math-related skills and tasks more than women do, it follows that men's math self-perceptions would have a strong effect on later choice of a science and math major, as was found. The current findings for women regarding the indirect effects of early math scores—through course-taking—are less consistent with Eccles's theory. According to Eccles's theory, it was expected that these indirect effects would be stronger for men.

Because of the strong effect of math self-perceptions for men, high school boys' and young men's self-observation generalizations about math deserve attention from counselors and educators. Note that this item elicited a self-judgment of participants' math skills relative to their other academic skills. Counselors could readily have students make such intra-individual comparisons in counseling. According to Krumboltz (1996), people may have inaccurate and misleading beliefs about themselves and their educational and career development. The counselor's role is to help young people challenge debilitating beliefs and validate facilitative beliefs. One means of enhancing self-awareness is to help young people structure new learning experiences.

For men, higher degrees of personal computer use resulted in a greater likelihood of later choosing science and math majors. This effect was also independent of course-taking. The National Education Goals Panel (1999) called for increases in the availability of computers in math classrooms. However, the computer use item in the present study likely reflected computer use at home. Trusty (2000) found that for boys with relatively low achievement and high postsecondary educational expectations, expectations were likely to remain high across the years of adolescence if a computer was available in the home. From Krumboltz's (1979, 1996) perspective, computer use represents a learning experience. On the basis of the results of the present study and the Trusty (2000) study, it seems important that counselors, educators, and parents ensure that this learning experience is available and encouraged for all students.

There was no effect of computer use on choice of science and math majors for women. Many more men than women choose computer science as a college major (National Center for Education Statistics, 2000b). Perhaps this fact explains the absence of an effect of computer use for women. That is, if very few women choose computer science majors (i.e., variability is low), the possibility of an effect is decreased. Inversely, if women do not engage in computer-related learning experiences, they are not likely to see computer science as a viable alternative.

Regarding the race–ethnicity variable, White men were least likely, as compared with other men, to choose a science and math major. Asian/Pacific Islander men were most likely to choose science and math majors. These racial–ethnic differences were present in bivariate and multivariate contexts. The race–ethnicity effect was strengthened somewhat in the multivariate context. That is, when early science and math scores were taken into account, racial–ethnic differences were amplified.

Findings regarding the Race–Ethnicity × SES interaction are similar to earlier findings of Trusty, Ng, et al. (2000). In this earlier study, the sample included students in all types of postsecondary educational programs, including nonacademic programs. However, there is sample crossover between this earlier study and the present study. In the present study, and for men only, the effect of race–ethnicity was conditional upon SES. Higher SES produced the largest increases in choice of science and math majors for Hispanics and African Americans. Therefore for men, SES tends to equalize choice of major for two groups traditionally underrepresented in science and math fields, namely Hispanics and African Americans (see Oakes, 1990; Trusty, Ng, et al., 2000).

For women, race–ethnicity effects were weaker and were not present in the bivariate context. However, the racial–ethnic effect was significant in the multivariate context. When early science and math performance was controlled, African American women were most likely to choose science and math majors and Native American and White women were least likely to do so. For women, there was no Race–Ethnicity × SES interaction.

It seems noteworthy that several variables did not have significant effects on choice of science and math majors. Students' general attitudes about school and education had only suppressor effects in the models for women (cf. Ware & Lee, 1988). SES had little bivariate or multivariate effect for women or for men. This finding is contrary to the findings of Trusty, Robinson, et al. (2000), who also used NELS:88 data. Trusty, Robinson, et al. found that SES had a positive effect on choice of science and math majors for women. This inconsistency is likely due to differences in samples and populations. Trusty, Robinson, et al. used a sample of students attending various types of postsecondary institutions, and students were not necessarily working toward a 4-year academic degree. Students working toward a 4-year degree, as in the present study, were higher and less variable in SES. For women, the amount of time spent on homework outside school had only an indirect effect, through course-taking. There was no effect of this variable for men. In the bivariate context, time spent on homework was weakly and positively related to choice of science and math majors for women and men.

In viewing the results of the current study within the broad context of career development theory and career choice theory, the results support divergence rather than convergence. That is, a "one-theory-fits-all" approach does not seem efficacious (cf. Lent et al., 1994). The processes of career choice for women and men seem to differ substantially, at least regarding choice of science and math majors and fields. Other evidence of gender interactions (e.g., Maple & Stage, 1991; Trusty, Ng, et al., 2000; Trusty, Robinson, et al., 2000; Ware & Lee, 1988) support divergence. There are many studies in the research literature that seek to support or disconfirm various career theories. Of these, most do not include gender as a variable. Many studies compare the genders on career-related variables, and these studies have some utility. Studies on one gender or the other also have some utility. However, few studies investigate the separate processes of career development or career choice for women and men. In this type of study, it is necessary to include several variables and to develop separate models for women and men. More studies of this type are needed to determine the applicability of various theories. More studies of this type are needed to inform counselors and educators about what to ask of clients and students, what to assess, and how to help young people in their career development.

I studied choice of science and math majors. Studies are needed on persistence in and completion of college degrees in science and math. For example, results from the present study revealed that African American women and men compared favorably with other racial–ethnic groups in choice of science and math majors. African Americans have traditionally been underrepresented in science and math fields (Oakes, 1990). There is a need for studies that identify course-taking or other variables related to completion of science and math degrees for African Americans.

Limitations of the present study include limitations associated with most secondary analyses. That is, in developing variables, the researcher is restricted to data that were collected, and often only a few items are available to quantify constructs or behaviors. Strengths of the study include the large nationally representative sample and the longitudinal nature of the data. The data were also comprehensive, covering various areas of students' functioning and experience across the years of adolescence.

REFERENCES

Adelman, C. (1999). *Answers in the tool box: Academic intensity, attendance patterns, and bachelor's degree attainment* [Monograph]. Retrieved December 18, 1999, from U.S. Department of Education, Office of Educational Research and Improvement Web site: http://www.ed.gov/pubs/Toolbox/Title.html

Agresti, A. (1990). *Categorical data analysis*. New York: Wiley.

Betz, N. E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior, 23*, 329–345.

Brody, L. E., & Benbow, C. P. (1990). Effects of high school coursework and time on SAT scores. *Journal of Educational Psychology, 82*, 866–875.

Chaney, B., Burgdorf, K., & Atash, N. (1997). Influencing achievement through high school graduation requirements. *Educational Evaluation and Policy Analysis, 19*, 229–244.

Davenport, E. C., Jr., Davison, M. L., Kuang, S. D., Ding, S., Kim, S., & Kwak, N. (1998). High school mathematics course-taking by gender and ethnicity. *American Educational Research Journal, 35*, 497–514.

Eccles, J. S. (1994). Understanding women's educational and occupational choices. *Psychology of Women Quarterly, 18*, 585–609.

Eccles, J. S., & Jacobs, J. E. (1986). Social forces shape math attitudes and performance. *Journal of Women in Culture and Society, 11*, 367–380.

Eide, E. (1994). College major choice and changes in the gender wage gap. *Contemporary Economic Policy, 12*, 55–64.

Hackett, G. (1985). Role of mathematics self-efficacy in the choice of math-related majors of college women and men: A path analysis. *Journal of Counseling Psychology, 32*, 47–66.

Harrington, T. F., Feller, R., & O'Shea, A. J. (1993). Four methods to determine RIASEC codes for college majors and a comparison of hit rates. *The Career Development Quarterly, 41*, 383–392.

Holland, J. L. (1966). A psychological classification scheme for vocations and major fields. *Journal of Counseling Psychology, 13*, 278–288.

Holland, J. L. (1997). *Making vocational choices* (3rd ed.). Odessa, FL: Psychological Assessment Resources.

Ingels, S. J., Dowd, K. L., Baldridge, J. D., Stipe, J. L., Bartot, V. H., & Frankel, M. R. (1994). *Second follow-up: Student component data file user's manual* (NCES Publication No. NCES 94-374). Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

Jones, L. V. (1987). The influence on mathematics test scores, by ethnicity and sex, of prior achievement and high school mathematics courses. *Journal for Research in Mathematics Education, 18*, 180–186.

Krumboltz, J. D. (1979). A social learning theory of career decision making. In A. M. Mitchell, G. B. Jones, & J. D. Krumboltz (Eds.), *Social learning and career decision making* (pp. 19–49). Cranston, RI: Carroll Press.

Krumboltz, J. D. (1996). A learning theory of career counseling. In M. L. Savickas & W. B. Walsh (Eds.), *Handbook of career counseling theory and practice* (pp. 55–80). Palo Alto, CA: Davies-Black.

Lee, V. E., & Bryk, A. S. (1989). A multilevel model of the social distribution of high school achievement. *Sociology of Education, 62*, 172–192.

Lee, V. E., Croninger, R. G., & Smith, J. B. (1997). Course-taking, equity, and mathematics learning: Testing the constrained curriculum hypothesis in U.S. secondary schools. *Educational Evaluation and Policy Analysis, 19*, 99–121.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior, 45*, 79–122.

Maple, S. A., & Stage, F. K. (1991). Influences on the choice of math/science major by gender and ethnicity. *American Educational Research Journal, 28*, 37–60.

McClure, G. T. (1998). High school mathematics course taking and achievement among college-bound students: 1987–1996. *NASSP Bulletin, 82*, 110–118.

Menard, S. (1995). *Applied logistic regression analysis*. Thousand Oaks, CA: Sage.

National Center for Education Statistics. (2000a). *The condition of education 1997: Indicator 24*. Retrieved February 16, 2000, from U.S. Department of Education, National Center for Education Statistics Web site: http://nces.ed.gov/pubs/ce/c9724a01.html

National Center for Education Statistics. (2000b). *Findings from the condition of education 1997: Women in mathematics and science*. Retrieved February 20, 2000, from U.S. Department of Education, National Center for Education Statistics Web site: http://nces.ed.gov/pubs97/97982.html

National Education Goals Panel. (1999). *The National Education Goals report: Building a nation of learners, 1999*. Washington, DC: U.S. Government Printing Office. (ERIC No. ED 433 377)

National Education Longitudinal Study: 1988–94: Data files and electronic codebook system [CD-ROM data files and documentation]. (1996). Washington, DC: National Center for Education Statistics [Producer and Distributor].

Norusis, M. J. (1994). *SPSS advanced statistics 6.1*. Chicago: SPSS.

Oakes, J. (1990). Opportunities, achievement, and choices: Women and minority students in science and mathematics. In C. B. Cazden (Ed.), *Review of Research in Education, Vol. 16* (pp. 153–222). Itasca, IL: Peacock.

Pedhazur, E. J. (1982). *Multiple regression in behavioral research* (2nd ed.). Fort Worth, TX: Holt, Rinehart and Winston.

Rosen, D., Holmberg, K., & Holland, J. L. (1997). *The educational opportunities finder* (3rd ed.). Odessa, FL: Psychological Assessment Resources.

Trusty, J. (2000). High educational expectations and low achievement: Stability of educational goals across adolescence. *Journal of Educational Research, 93*, 356–365.

Trusty, J., & Ng, K. (2000). Longitudinal effects of achievement perceptions on choice of postsecondary major. *Journal of Vocational Behavior, 57*, 123–135.

Trusty, J., Ng, K., & Plata, M. (2000). Interaction effects of gender, SES, and race-ethnicity on postsecondary educational choices of U.S. students. *The Career Development Quarterly, 49*, 45–59.

Trusty, J., Robinson, C., Plata, M., & Ng, K. (2000). Effects of gender, SES, and early academic performance on postsecondary educational choice. *Journal of Counseling & Development, 78*, 463–472.

Ware, N. C., & Lee, V. E. (1988). Sex differences in choice of college science majors. *American Educational Research Journal, 25*, 593–614.