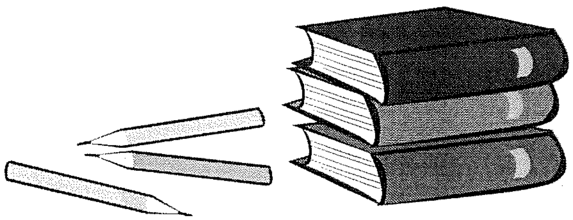
CAREER CHOICE

Planning Early for Careers in Science



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Young adolescents who expected to have a career in science were more likely to graduate from college with a science degree, emphasizing the importance of early encouragement.

Concern about U.S. leadership in science has captured the national spotlight once again (*1*). The physical sciences and engineering are at particular risk, with declines in the number of earned doctorates in these fields among U.S. citizens and permanent residents in the past decade (*2*) (figs. S1 to S3). Recommendations for improvement focus on education, particularly in improving the number of teachers and the quality of teacher training for primary and secondary schools (*1*). This is an attractive but expensive approach.

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How important is it to encourage interest in science early in children's lives? How early in their lives do students decide to pursue a science-related career? We used nationally representative longitudinal data to investigate whether science-related career expectations of early adolescent students predicted the concentrations of their baccalaureate degrees earned years later. Specifically, we asked whether eighth-grade students (approximately age 13) who reported that they expected to enter a science-related career by age 30 obtained baccalaureate degrees in science-related fields at higher rates than students who did not have this expectation. We analyzed students in the United States for years 1988 through 2000 and controlled for differences in academic achievement, academic characteristics, and students' and parents' demographics.

Survey and Analysis

We used the *National Education Longitudinal Study of 1988* (*NELS:88*) for this study. Designed and conducted by the National Center for Educational Statistics (NCES), *NELS:88* began in 1988 with a survey of 24,599 eighth graders. Researchers conducted additional surveys in 1990, 1992, 1994, and 2000. The overall sample size after five surveys was 12,144 participants. Our analysis focused on those students who responded to the question about their age 30 career expectation as eighth graders in 1988 and who also obtained baccalaureate degrees from 4-year colleges or universities by 2000. This reduced the sample to 3,743 participants. The sample was further reduced to a final size of 3,359 participants, because 384 participants were missing data in one or more of the variables used in the analysis.

MULTINOMIAL LOGISTIC REGRESSION ANALYSIS

Independent variable		Coefficients of nested models Baseline	2	3	4	Final
Career expectation	Life sci.	0.6 (0.2)	0.7 (0.2)	0.7 (0.2)	0.6 (0.2)	0.7 (0.2)
	Phy. sci. /engr.	1.7 (0.2)	1.4 (0.2)	1.2 (0.2)	1.2 (0.2)	1.2 (0.2)
Covariate groups						
Student demographics			+	+	+	+
Achievement scores				+	+	+
Academic characteristics					+	+
Parent background						+

Regression analysis results. $P < 0.001$ for all data shown; + indicates inclusion of covariates in the model; standard errors are shown in parentheses; $n = 3359$. Dependent variables: nonscience = 0, life science = 1, and physical science/engineering = 2. See supporting online material for more details.

These variables included scores from mathematics and science achievement tests (designed by the Educational Testing Service) that were administered in the first three surveys of data collection, when students were mostly enrolled in the 8th, 10th, and 12th grades (*3*, *4*).

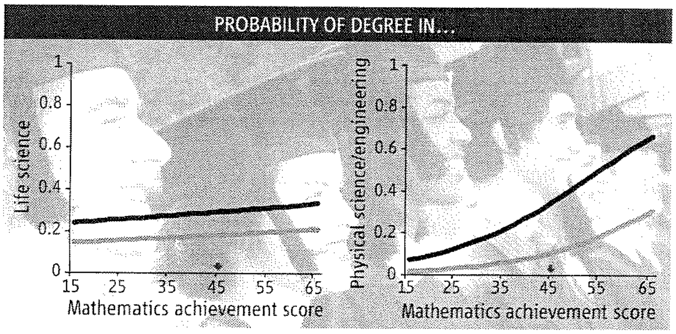
The baccalaureate degree concentrations—which were coded into three broad categories of physical science/engineering, life science, and nonscience—resulted in a categorical dependent variable (tables S1 and S2 and supporting online material text) (*5*). The independent variables used in this analysis came from data collected when participants were enrolled in the eighth grade.

In our analysis, we took into account students' backgrounds and natural propensities. For example, students with stronger performance in science and mathematics may be more likely to major in the sciences. We therefore included four covariate groups to account for (i) academic backgrounds (science and mathematics achievement scores); (ii) students' demographics (gender and ethnicity); (iii) students' academic characteristics (enrollment in advanced versus regular mathematics and science classes, attendance in these classes, and student-reported attitudes toward mathematics and science); and (iv) parents' background (highest educational level and professional versus nonprofessional employment) (*6*).

Our analysis focuses on the independent variable derived from the *NELS:88* survey question: "What kind of work do you expect to be doing when you are 30 years old?" Students were then given a list of employment options and required to select only one. We categorized the responses into two groups: science-related and nonscience career expectations, creating the Career Expectation independent variable (*4*).

We applied multinomial logistic regression, which handles categorical dependent variables with more than two outcomes. Our analysis included two outcome comparisons in earned baccalaureate degrees: (i) earning degrees in life sciences versus nonscience areas and (ii) earning degrees in physical sciences/engineering versus nonscience areas. We assessed the degree to which the independent variables could predict these two comparisons. In the *NELS:88* sampling design, two analytical issues require special attention: (i) the effect of purposeful

PROBABILITY OF DEGREE IN...



Estimated probability comparisons. Probability that students who, in eighth grade, expected (dark line) or did not expect (light line) a science career would achieve a life science degree (left) or a physical science/engineering degree (right). Blue arrow designates the average mathematics achievement score.

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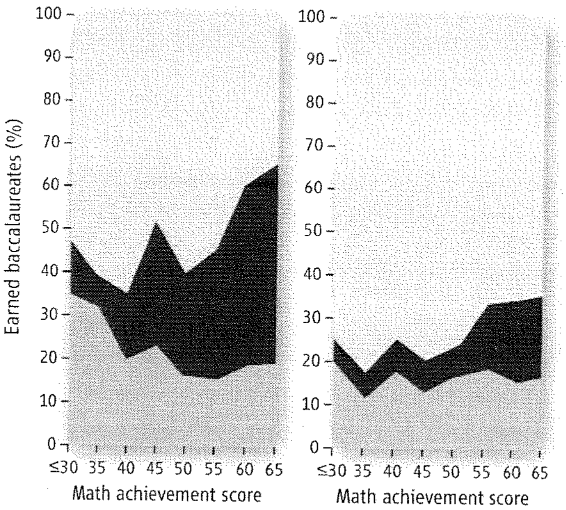
oversampling of some ethnic and minority groups and (ii) the effect of multistage cluster sampling on standard error estimation. We followed the NCES guidelines by using sampling weights for statistical analyses (*3*). We accounted for the complex sampling design by using the STATA 9.0 statistical software package (*3*, *7*).



Proportion of earned baccalaureates. Degrees in life science (light green), physical science/engineering (dark green), and nonscience fields (gray). Students who in eighth grade expected a science degree are shown on the left (n = 337); those who did not expect a science degree are shown on the right (n = 3022).

Results and Discussion

Our analysis began with a baseline model that included only the Career Expectation independent variable and continued with successively more complex models systematically accounting for each of the four covariate groups (see table on page 1143 and table S7).

As more independent variables were included in the nested models, the coefficient remained unchanged for the life science outcome. For the physical science outcome, the coefficient at first attenuated from its initial value and then settled into a robust value after model 3. This behavior is common in such analyses because variance accounted for by initially entered variables is subsumed by successive variables. We also checked for interactions between Career Expectations and the other independent variables and did not find them to be significant at the $P = 0.05$ level.

The odds ratios, calculated from the final model, were 1.9 for life sciences versus nonscience and 3.4 for physical sciences/engineering versus nonscience (table S7). This result suggests that, among the students who graduated with baccalaureate degrees from 4-year colleges, those who expected as eighth graders to have science-related careers at age 30 were 1.9 times more likely to earn a life science baccalaureate degree than those who did not expect a science-related career. Students with expectations for a science-related career were 3.4 times more likely to earn physical science and engineering degrees than students without similar expectations.

Next, we considered the estimated probabilities of earning science baccalaureate degrees produced by the final model comparison (see figure on page 1143). For life sciences, estimated probabilities nearly doubled for students who reported science-related career expectations compared with those who did not. For example, a prototypical student expecting a science-related career has an estimated probability of obtaining a life science degree of 29% compared with 18% for a prototypical student expecting a nonscience career, with all other predictors set to the means. Eighth-grade mathematics achievement was not a significant predictor for life science degrees.

However, for physical science/engineering degrees, the result was quite different (see figure on page 1143, right panel). High mathematics achievers were much more likely than low achievers to earn these degrees. For example, let us compare the estimated probabilities for two pairs of prototypical students with all other variables set to means. Suppose the first pair has average mathematics achievement scores (average math achievement score at eighth grade = 45, SD = 11). Here, the estimated probability of earning a physical science or engineering baccalaureate degree for the student who expected a science-related future career was 34%. In contrast, for the student who expected a nonscience career, the estimated probability was 10%. Suppose that for the second pair, we have high mathematics achievers whose test scores were one standard deviation above average. Here, the estimated probability of the student who expected a science-related future career was 51%, whereas the estimated probability of the student who expected a nonscience career was 19%. To the extent that taking courses encourages expectations, this result supports the National Science Board's contention (*8*) that mathematics courses taken in grades 7 and 8 have an impact on the physical sciences and engineering workforce.

There is an additional comparison across these pairs that should not go unnoted. An average mathematics achiever with a science-related career expectation has a higher probability of earning a baccalaureate degree in the physical sciences or engineering than a high mathematics achiever with a nonscience career expectation, 34% versus 19%. We make this comparison not to minimize the importance of academic achievement, but rather to highlight the importance of career expectations for young adolescents.

We analyzed (see figure at left) the proportion of students who earned the three types of baccalaureates degrees, according to eighth-grade expectations and math achievement scores. Most notable is the proportion of students who, in a sense, followed through on their eighth-grade science career choices—roughly half. In contrast, proportionally fewer students who reported nonscience career expectations switched into science—roughly a third.

Much effort has been focused on raising test scores and promoting advanced courses at later ages; however, we should not overlook the likelihood that life experiences before eighth grade and in elementary school may have an important impact on future career plans. Although our current analysis does not provide proof of an uninterrupted causal chain of influence, our study does suggest that to attract students into the sciences and engineering, we should pay close attention to children's early exposure to science at the middle and even younger grades. Encouragement of interest and exposure to the sciences should not be ignored in favor of an emphasis on standardized test preparation (*9*).

References and Notes

1. National Research Council, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Future* (National Research Council, Washington, DC, 2005).
2. Data obtained through WebCASPAR (http://caspar.nsf.gov/).
3. National Center for Educational Statistics, *User's Manual: National Education Longitudinal Study of 1988* (NCES, Washington, DC, 2004).
4. D. A. Rock, J. M. Pollack, "Psychometric report for the *NELS:88* base test battery" (Tech. Rep. NCES 91-468, National Center for Educational Statistics, Washington, DC, 1991).
5. N. Hativa, M. Marincovich, *Disciplinary Differences in Teaching and Learning: Implications for Practice* (Jossey-Bass, San Francisco, CA, 1995).
6. Occupational classifications are highly complex and, in this analysis, only limited data were available on parents' specific occupations. We paid special attention to parental occupation in this analysis, because conventional wisdom suggests that children whose parents have careers in science may be more likely to choose similar careers. However, the existing data related to parents' occupations were reported in categories that did not specify whether jobs were science related. As a result, we chose to use the broad categories of professional versus nonprofessional.
7. For a more detailed discussion of this technique, please see J. S. Long, J. Freese, *Regression Models for Categorical Dependent Variables Using STATA®* (STATA, College Station, TX, 2001).
8. National Science Board, *An Emerging and Critical Problem of the Science and Engineering Labor Force: A Companion to the Science and Engineering Indicators 2004* (National Science Board, Washington, DC, 2004); available online (www.nsf.gov/statistics/nsb0407/ nsb0407.pdf).
9. S. Dillon, "Schools cuts back subjects to push reading and math," *The New York Times*, 26 March 2006 (www.nytimes.com/2006/03/26/education/26child.html).
10. This study was funded in part through a grant from NSF, Directorate of Education and Human Resources, Division of Research, Evaluation, and Communication, Research on Learning and Education Program (REC 0440002, Project Crossover). We thank L. E. Suter (NSF), D. Herschbach (Harvard University), and D. R. Webb (Proctor and Gamble) for their comments.

Supporting Online Material
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